



ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF COMPUTING

**An Efficient Requirement Engineering Process for Improve
Healthcare IT Project**

DAGNACHEW GETACHEW

Jan 2017



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**An Efficient Requirement Engineering Process for Improve
Healthcare IT Project**

**A Thesis submitted to School of Graduate Studies of Adama Science and Technology
University in Partial Fulfillment of the Requirements for the Degree of Master of Science in
Software Engineering**

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Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other work and that all source of materials used for the thesis has been duly acknowledged.

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Acknowledgement

First and for all, I would thank the almighty of GOD for granting me knowledge, health, and the patience to successfully complete this thesis.

I would also like to show my gratitude and appreciation to the following people:

Firstly, my advisor Dr. Mesfin Abebe, my supervisor, for his generous and constructive feedback and continuous encouragement constructive feedback for the report and valuable comments in the progress meetings throughout the thesis.

Secondly, Special thanks and gratitude go to all my colleagues and friends, especially Frezer Guteta, Seifu Berihanu, Anbesa Jimma, Mati Oljira Jemal Nuraddis, Amensisa Debele and Endires.M who have been there encouraging me on and supporting me.

Finally, I would like to express my obligatory to my parents, my brothers, and my sisters who have always been supportive and encouraged me morally.

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Acronyms and Abbreviation

IT	Information Technology
ICT	Information and Communication Technology
E-HIS	Electronic Health Information System
HIS	Healthcare Information System
MOH	Ministry of Healthcare
RE	Requirements Engineering
DHIS	District Healthcare Information System
SDLC	Software Development Life Cycle
AREDM	Agile Requirement Engineering Development Method
TREDM	Traditional Requirement Engineering Development Method
PASDEP	Plan for Accelerated and Sustained Development to End Poverty.
GOE	Government of Ethiopia
SPM	Strategic Planning and Management.
BPR	Business Process Reengineering.
FMOH	Federal Ministry of Health.
HSDP	Health Sector Development Program.
HMIS	Health Management Information System.
HMIS/ ME	Health Management Information System /Monitory and Evaluation.
HRIS	Human Resource Information System
HIFIS	Health Integrated Financial Information System
XP	Extreme Programming
FDD	Feature Driven Development.
DSDM	Dynamic System Development Method
ASD	Adaptive Software Development
RUP	Rational Unified Process.
HEW	Health Extension Worker
HITS	Healthcare Information Technology Staff
PPITD	Plan and Police Information Technology Directorate
HITD	Healthcare Information Technology Directorate

UML	Unified Model Language
DFD	Data Flow Diagram
ERD	Entity Relationship Diagram
WBRGS	Web Based Requirement Gathering System
ASP	Active Server Page
CSS	Cascading Style Sheets

Abstract

Requirement engineering process is essential for develop an efficient software development in the software industry. E-healthcare is one of the critical software industry and it is crucial systems for Ethiopia which increase the life expectancy of the people and reduce the cost of medical treatment and time wastage. Due to requirements engineering process and the absence of the rigorous approach in the development of the healthcare IT projects, were not a success and satisfied the stakeholders in Ethiopia. Additionally, most of the healthcare IT projects were developed through partner and some of them customized from another country. Thus, the systems were coming with failures and asked additional cost to took training and there was not user involvement in the development process of software and no requirement change management in software development life cycle at any phase. We investigate requirement engineering process of the healthcare system and develop requirement elicitation technique to improve healthcare service delivery to stakeholders.

To address problems, we have been used the method Scrum Agile Requirements engineering approach which has four software development life cycle phases:(Elicitation, Analysis and Design, Specification and Implementation, Validation and Documentation). The research is empirical research type which solves the problem systematically and we conducted this thesis through review different literature and identify the gap, interview, questionnaire, observation and document analysis. Finally, we evaluate the proposed model using different metrics and develop a web based requirement gathering system prototype which increases the quality of requirements elicitation and reduce the time consuming during elicitation and error on the requirement. Additional to this it reduces the wastage of resource and labor force, and it used to better communication between the developer and stakeholders.

Chapter One: Introduction

1. Background of the Study

Health information technology (health IT) aims to use information and communication technology in healthcare to support the delivery of healthcare to patients or to support patient self-management [1]. The last century has produced a proliferation of requirement engineering process in the healthcare industry aimed at enhancing life expectancy, quality of life, diagnostic and treatment options, as well as the efficiency and cost-effectiveness of the healthcare system [2]. The meaning of the scenario that before software engineering is innovated there is no such healthcare information system in the previous year.

Healthcare industry's focus is to provide quality healthcare services to its consumers i.e., their patients. Information and communication technology is being used by the healthcare industry to enhance the quality of services. This industry is dynamic in nature. The dynamics increase complexity with respect to technology, medical needs, and organizational needs. Identifying those dynamic features and its interactions lead to definition, development, and implementation of systems. Integration of computer and information technology with such systems in software development healthcare has given rise to a new area of study that health informatics and e-Health. The health informatics is associated with activities like communication, structuring, questioning, searching and making decisions with health information. The intervention of informatics in health helps reducing human errors in healthcare. Healthcare is now more than simply medical care and treatment. The goal of healthcare is to provide more efficient services to enjoy a healthy society. Therefore, healthcare information system is a comprehensive, integrated and designed to manage the medical and administrative aspects of a medical organization [3].

Many information technology companies in Ethiopia under the umbrella of health IT board today have built healthcare software commonly known as e-health software. These are many information systems where data is processed and used within and across the systems [4]. This dynamic calls for a better definition of models (prototypes) from which the information system is developed. But all the healthcare information system didn't focus on the requirement engineering process and follow a good requirement engineering model approach to increase the quality of healthcare service delivery to the user and satisfaction needs of stakeholders.

The new system, which called District Healthcare information system (DHIS) used to improve the quality of service delivery and meet the requirement with the need of stakeholder. Most E-health Projects in Ethiopia failed at pilot level [5]. The new proposed system is giving the great attention to the requirement engineering process which includes user participate in the develop system in the ministry of health in Ethiopia. The DHIS is a system which used to store data about healthcare, gather information, and manipulate the data, equal distribution of healthcare in the country. It also increases the quality of healthcare service delivery, increases the satisfaction of stakeholders, reduces medical errors and reduces the cost of healthcare.

The requirement engineering process has the great impact on the development system the in healthcare IT project, in Ethiopia, the requirements are elicited from different district of the country through the health worker extension by using the new proposed system which is called web based requirement gathering for a system the development.

Most of the time there is no healthcare system development, using scrum agile requirements engineering method in Ethiopia. When we develop a system in healthcare it should be using the rigorous method. Thus the method which used to understanding the need of stakeholders and involve the user in developing projects. We proposed the rigorous methodology in healthcare of Ethiopia which called agile system development method using scrum. The main principle of agile methods is to be able to work flexibly with the development of systems.

1.1. Statement of the Problem

According to S.Fricker [1] health care service delivery is greatly linked to computer technology and other technological tools. There have been many implementations of IT projects or software in the healthcare sectors. In today's E-health scenarios, the notion of completeness of health information systems and ICT are questioned by healthcare professionals [6]. Health-care is today one of the fastest growing economic sectors, where on the other hand huge amounts of money are wasted because of the errors at the requirements engineering stage.

The fundamental problems in requirements engineering have been identified by many researchers. There have been many implementations of IT software in the healthcare sector. However, in every project, there is some change of requirements that finally directs to unfinished/incomplete [7]. The problem is service providers and service users' needs are not fulfilled on the requirement of the system. The other problem, in E-healthcare project the developer not putting enough requirement engineering process instead they iterative service delivery of the system by ignoring

the agile approach and they customize the system without their requirement. In E-health project, requirement engineering process is neither clearly stated nor well managed especially in Ethiopia case.

On the other hand, the best practice in healthcare environment need store the system requirement with existing system. But, there is not documented system requirements and no integrated with the existing E-health project. In healthcare, the need of service users or stakeholders and professional dynamically changing from time to time, so documenting the best practice will help to adopt the change. Healthcare service requirement engineering is essential that in e-health care system is the information processing at all-time patient health-centric issue. Security and the privacy of patient are other factors that require attention at the time of requirement engineering phase. Increasing costs, the complexity of the business processes within the healthcare sector, incompetent management of such business processing leading to variability in the quality of care, limitations on physical access to the patient records etc. have been some of the intrinsic characteristics of the healthcare industry in the past.

In a recent day in Ethiopia requirement engineering process is essential in e-health care service delivery system, but in Ethiopia, there is no fulfillment of requirement engineering to develop the software e-healthcare projects. The developed healthcare IT projects functionality is differently based on the different stakeholders. Thus, the system raises the problem of unsatisfied the needs of patients and stakeholders based healthcare service delivery because the requirements must be met the needs of end users functionally. Any healthcare developed based on the requirement change in developing life cycle has been high quality and most model has their method to manage the change of requirement in software development life cycle. In Ethiopia, most several years the E-healthcare IT projects didn't follow the clear and well define an approach that used manage the change of requirements in that project.

1.2. Research Question

Generally, to solve the problem we rise the following research questions

1. What are the impacts of requirement engineering process in E-healthcare?
2. How requirement engineering is the impact of change on the requirement and used in the delivery of projects?
3. What are types of approach we used to meet the requirement change from stakeholder?

4. Why is flexible approach important to effort be enhance through effective communication in e-healthcare?

1.3. Objectives of the study

1.3.1. General Objective

The main objective of this study is to investigate the requirement engineering process of healthcare systems and develop requirements elicitation technique to improve healthcare service delivery for all stakeholders.

1.3.2. Specific Objective

- ✚ Identify the existing requirements engineering process in healthcare
- ✚ Develop suitable requirements engineering model in healthcare IT project.
- ✚ Analysis RE activities and Scrum activities
- ✚ Develop an integrating model with scrum agile approach
- ✚ Evaluated the proposed model.
- ✚ Evaluate the requirement engineering process and the approach or model in e-health care system.
- ✚ Verify and validate the requirements by requirement engineering process techniques.

1.4. Scope and limitation of the Study

The scope of this requirement engineering process for healthcare IT projects and more concentrated on efficient approach, in the healthcare system of Ethiopia health sectors using requirement engineering process and scrum agile approach, to improve the quality of requirements and increase the satisfaction of stakeholders. The chance of getting moderate and software industry in E-healthcare system is too rare, so it is difficult to get available information easily. The other limitation is the requirement met inefficient way to fill the required and there are no trends of developing software following requirement engineering process and using the agile approach in Ethiopia.

1.5. Significance of the Study

The major finding of this study is for individual patients, ministry of health, service provider, health professionals and health software industry of Ethiopia.

The aim of this research is to analyze the software engineering process in healthcare which includes requirement engineering process techniques and the right agile approach in order to fill the needs of stakeholders in developed healthcare system; which giving the quality health service for community and cost effectiveness of software development process.

To analyze an individual sector that getting service from this research are:

- **With respect to patient-:** it helps the patient to get quality health care service delivery and support access the system from a different place and at a different time. And it also satisfies their needs according to the stated requirement by patients and gets the medicine at minimum cost, decreases treatment barrier. With this scenario, the patient has got those service from the developed system when the system was developed through requirements engineering and using the rigorous approach.
- **For the ministry of healthcare-:** it uses to making a decision on the requirement and used for analysis the coverage of E-healthcare service delivery for the citizens. It also uses easy management.
- **For service provider (developer) -:** use for technically identify the requirement and analysis the problem on the thus requirement. It also uses for clearly putting the functional and non-functional requirement of the development software and use for easily administration of the information flow, a better understanding of the needs of stakeholder and human labor force (skills).
- **For health professional -:** more less the healthcare IT projects has high quality developed through requirements engineering and scrum agile approach. So, they used to support clear medical treatment for the patient based on the best requirement and manage the requirement in e-health projects. It also uses for information/ knowledge sharing and uses time management.

1.6. The structure of the Thesis Documents

In chapter two gives an overview of the background of requirement engineering process that used to draw the conceptual literature review and related works. The related works criticized and show different methodology. It includes the basic description of requirement engineering process and the role of requirement engineering in the healthcare industry. The main contribution of this

chapter is analysis and find the gap of requirement engineering process in healthcare and after review, we draw the hypothesis of the thesis which supports with evidence of the requirements.

Chapter three mainly focus on the research methodology and identify the stakeholders that help to give the clear information to proposed problem. It also has a basic describe a different method that to used gathering data and description research type. Chapter four mainly point out the proposed solution to the problem that discusses in chapter one. In this chapter define the expected solution which helped by the objective of the research and we decide the scrum agile model.

Chapter five describe the main result and evaluation of the proposed solution using different attribute. In this chapter, the data gathered in chapter three are analyzed and evaluated the model in the case study. The case study shows the gap of requirement engineering process E-healthcare in Ethiopia. This chapter also determines and distinguish which appropriate approach used to solve the problem.

Chapter six talks about the implementation of the prototype and advantage gathering requirement through the web-based system have more quality rather than manual one. Finally, the last chapter (chapter seven) describes the conclusion of the thesis and further study required in requirement engineering process in E-healthcare of Ethiopia.

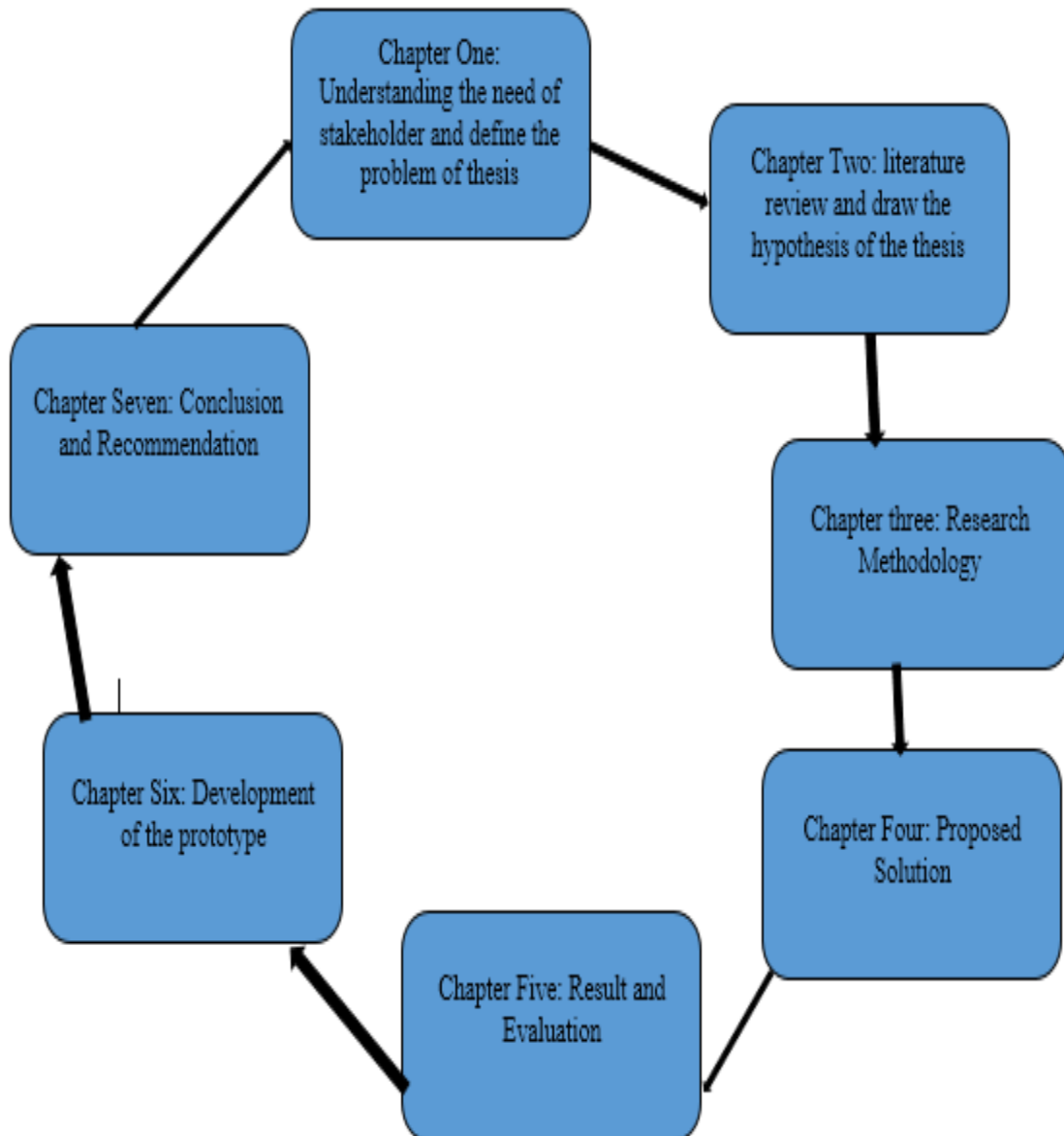


Figure 1.1: The Structure of the Thesis

Chapter Two: literature Review and Related Work

2. Literature Review

2.1. Requirement Engineering Process and ICT in Healthcare

As we review different kinds of requirements engineering process research papers, we understood that the requirement engineering process has been the great impact on the failure or success of any healthcare IT projects. Due to the requirement engineering process, around 76% of any healthcare IT projects are failing [8, 7]. To use the requirement engineering process to develop healthcare IT projects the researcher used different approaches. Most of the researcher use agile approach rather than uses the traditional approach because the requirement of stakeholder needs may change; to manage the change of any requirement on the project we can tolerate through the agile approach. Additionally, most of the project must meet the need of any stakeholders to satisfy their needs, to fulfilled the needs of stakeholder and to solve the problem of requirement engineering process on the project that we must be used the agile approach but every engineering, innovation and other field didn't use the agile approach because the big project such as construction, which used fixed requirement.

Now a day most of the researcher used in most of their research agile approach inform of adaptation practice. We draw the hypothesis from the next section of literature after review it. This section shows as the different researcher that doing their research on the requirement engineering process.

Requirements engineering is, as its name suggests, the engineering discipline of establishing user requirements and specifying software systems. There are many definitions of Requirements Engineering [9]; however, they all share the idea that requirements involve finding out what people want from a computer system, and understanding what their needs mean in terms of design. Requirements engineering is closely related to software engineering, which focuses more on the process of designing the system that users want. (RE) is the process of discovering that purpose, by identifying stakeholders and their needs, and documenting these in a form that is amenable to analysis, communication, and subsequent implementation". Requirements Engineering (RE) is a specific discipline of the software engineering. The RE process is recognized as being the most

critical process in software development. Errors made during this process may have negative effects on subsequent development steps, and on the quality of the resulting software.

However, software development engineers creating software with which to support many complex domains, such as healthcare, do not pay enough attention to the requirements engineering tasks. Health-care is a domain where the supporting software has to be perfectly designed in order to provide systems interoperability, integrate various devices and distributed software systems, execute complex automated or interactive business processes, while fully satisfying all the stakeholder's requirements and keeping the software understandable and user-friendly. Health-care is today one of the fastest growing economic sectors, where on the other hand huge amounts of money are wasted because of the errors at the requirements engineering stage.

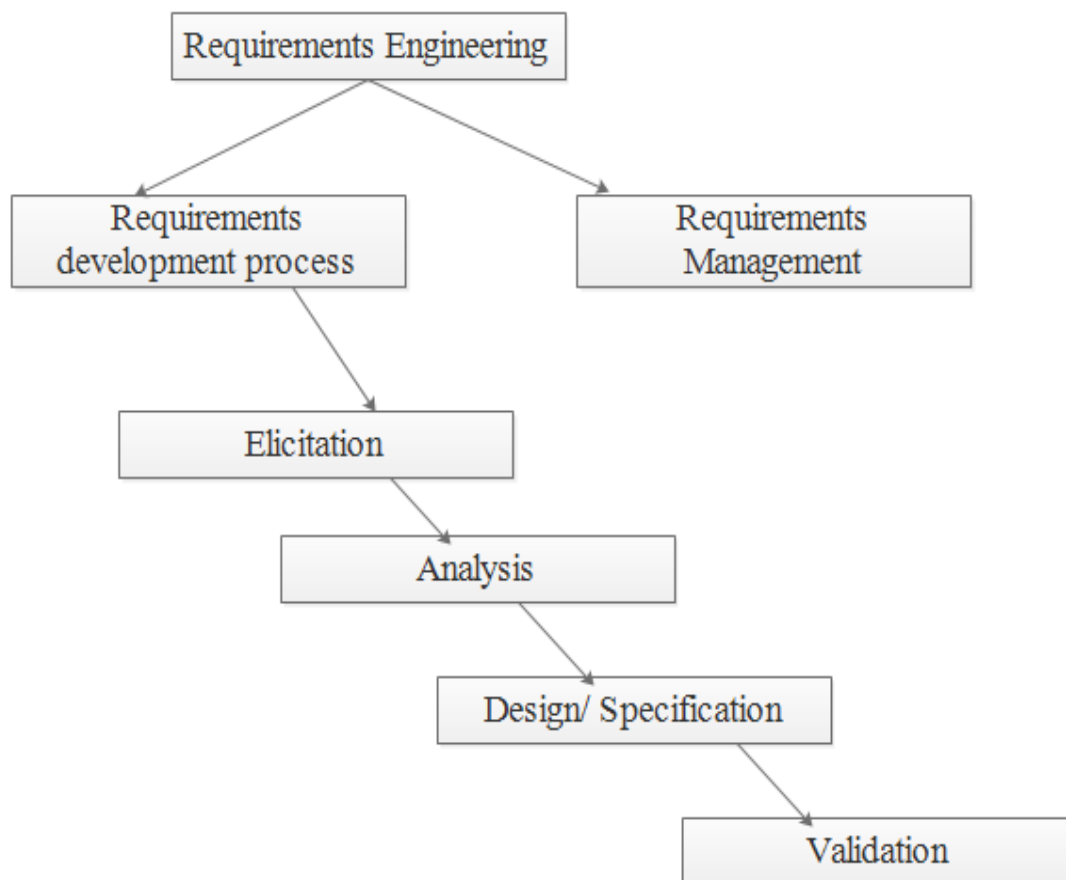


Figure 2.1. Requirements engineering sub disciplines [8]

In [8] requirements engineering process is state and put the requirement for the initial step of software development activity in which the requirements from the customer are elicited and documented. The most important requirements engineering goals were shared understanding between the project team and its stakeholders and good quality of the requirements specification. These two objectives of requirements engineering were often complemented with the need for a clear scope for the development, for using little time and resources for requirements engineering, for satisfying the users, and for delivering the requirements engineering work results in time.

The most common goal pursued by the software products that were specified with the requirements are productivity improvement. This goal was complemented by a variety of goals that included effectiveness, e.g. to enable users to do things they could not do before, compliance with laws and regulations, and satisfaction of users and stakeholders with the product. Important societal topics, like environmental or societal challenges, were rarely considered to be a goal of the software product [10].

In [8, 11], Requirements Engineering (RE) is a set of activities concerned with identifying and communicating the purpose of a software-intensive system and the contexts in which it will be used. Hence, RE acts as the bridge between the real-world needs of users, customers, and other constituencies affected by a software system, and the capabilities and opportunities afforded by software-intensive technologies.

RE in software development is a methodical approach to the specification and management of requirements. RE discipline focuses on both the problem and the solution required. RE interferes with system engineering to analyze and define the problem and suggests the required different functionalities out of the software. The processes used for RE vary widely depending on the application domain, the people involved and the organization developing the requirements. RE is a collateral process which needs to be carried out throughout the project in agile environments [8].

Requirements engineering is used to building hypothesis for the research and evaluating that hypothesis which affects the development of healthcare IT projects. Good requirements engineering enables socio-technical alignment: the software product or service adapts to needs and expectations, the stakeholders adopt, use, appropriate, and internalize it. Analysis potentials so that businesses can better comprehend vital system aspects before they actually develop the system.

The non-functional characteristics of the business are believed to be harder to encapsulate in business process modeling, as the focus of the modeling is on functional behavior [12]. In situations where patients are involved, security and safety are critical. Security goals evolve when stakeholders ascertain that tangible or intangible objects in the context of the system have a direct or indirect value that the stakeholders want to protect. Based on these goals, security requirements are derived as constraints on the functional requirements. For information security to be effective it must be built into the software development process rather than affixed to an already insecurely designed system. Appropriate security requirements that are well lined up with the business goals are indispensable for a secure design that improves product capability and return on investment [6].

According to the software development life cycle, requirement engineering process is the most critical process of system development and it also has significant importance in each stage of system development. RE is a continuous process in which all the related activities are repeated until the acceptable quality of requirements is not gathered. It has a formal starting and ending point, in start it is recognized that a problem exists and needs a solution for that or it's a new idea which has to be implemented. In the end, we have a complete description of the external behavior of the system which needs to be developed. Requirements engineering process deals with determining, demonstrating, communicating and documenting the requirements for a system that has to be built, and the contexts in which the system will be used. Most of the traditional software development process RE process has different activities [13, 14]: requirement elicitation, analysis, and negotiation, documentation, validation, and management. The following figure2 illustrate the activities of the RE process.

2.1.1. Type of Requirement Engineering Process Activities

There are five types of requirement engineering process activities [14].

1. Requirements Elicitation
2. Analysis and Negotiation
3. Documentation
4. Validation
5. Management

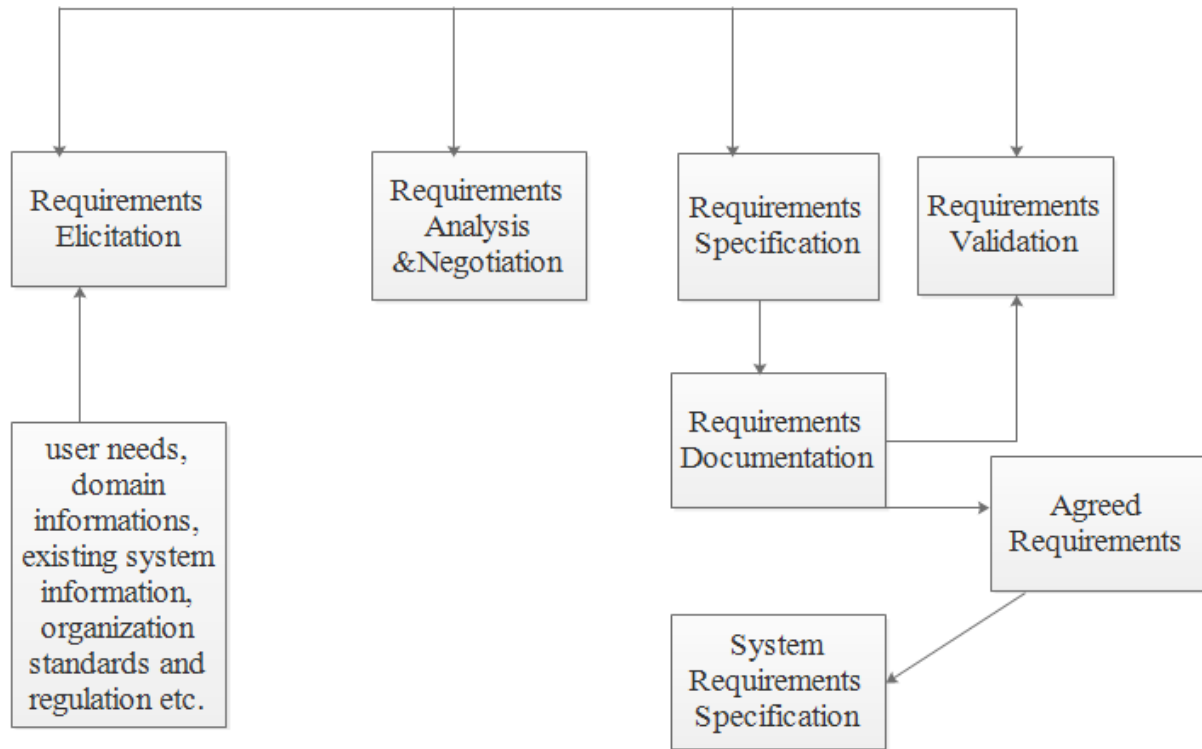


Figure 2.2. Requirement Engineering Process [14]

1. Requirements Elicitation

Requirements elicitation is the process of discovering and elaborating the requirements of a system. These requirements could be very well understood, fuzzily understood, or innovative problem. It is also performed by determining the system requirements through consulting the stakeholders, from system documents, domain knowledge and through market studies. Generally, this task requires a very good knowledge not only of the application domain but also of the specific problem the system is trying to solve. Previous work in requirements elicitation focused mainly on solutions that improve the precision, the accuracy, and the different levels of details for requirements [11].

In [15] examined an organization-wide adoption of agile practices at Nokia, and their results revealed that respondents agreed with the benefits of agile usage, including higher satisfaction and effectiveness, increased quality and transparency, and earlier detection of faults and that 60% would prefer to stay with the methods than return to their previous ways of working. Thus, this company developed the system based on the requirement engineering process and used an agile approach but not define which kinds of agile approach they used.

Many methodologies have been proposed for the elicitation of requirements, in which they are used most of the time for identification stakeholders need, similarly ensuring that the requirements are not diverted away from the scope of the project, which increases personal understanding about the gathering requirement and comparisons when it needs to understanding the phrase of different speech of verb so, we considering the context and the environment, in which the system will be deployed, as well as the stakeholder, needs when extracting the requirements of the system and finally, identifying the expectation and predict of requirements to help making the final product more attractive and likeable, such as brainstorming and creativity workshops [16, 17].

2. Requirements Analysis and Negotiation

It is used to understanding the relationships among various customer requirements and shaping those relationships to achieve a successful result. Negotiations regarding requirements are done in between stakeholders and requirement engineers. Inconsistent and incomplete requirements are tackled in this stage also some negotiations regarding budget should be discussed in this stage as well. Additionally, at stage solve the conflict of the requirements and stakeholder needs.

3. Requirements Specification (Design)

This is one of the important steps which can affect later steps or phases significantly if not catered carefully. In this, a tangible form of requirements is made using natural language and diagrams. This document should be made in that form so that it can be assessed for correctness, completeness, and consistency.

4. Requirements Documentation

The requirements document is mainly used by the designers, developers, and testers. This contains the detailed information of each and every requirement.

5. Requirements Validation

This process is intended to detect problems in the requirements document before they are used as a basis for the system development. It involves reviewing the requirements model for consistency and completeness.

6. Agreed Requirements

Finally, after all of the steps an agreed form of requirements is generated on which an agreement is made between the organizations. It will be used in later phases of Software development life cycle and testing. Without a doubt, traditional requirements engineering process is a thorough process and each activity is given a particular attention. In addition, one of the most important

activities of traditional software requirements engineering process is documentation. In fact, traditional requirements engineering process pays a great deal of attention to documentation [13] [14].

In general, software engineering involves the analysis, design, implementation, testing, maintenance and documentation of software systems. According to the Software Engineering Institute at Carnegie Mellon University, software engineering is that form of engineering that applies the principles of computer science to achieving cost-effective solutions to software problems [18]. Based on the above article or difference source of the requirement engineering process definition it must follow the software development life cycle process. It also determines the success of every software development and used to increase the quality of service delivery of product system.

2.2 Requirement Engineering in Healthcare

Requirements engineering for home health care is a hard process as it involves a number of stakeholders including the patient, primary doctor, other doctors, nurse, formal caregiver, informal caregiver, government agencies, and other agencies. Home healthcare systems encompass a number of stakeholder's who have different interests and are capable of impacting the performance, operation, and behavior of the system in different ways [19, 20].

The first steps need to be set right for the complete development cycle to deliver the required final product. Within the RE process of the e-health projects, each step/ phase is equally important. The different approaches in each phase serve as a basis for RE and thus quality certification of the end product. The requirements elicitation is the crucial first step in RE process where listening to the stakeholders, understanding their needs and getting their feedback to confirm that the need or the business problems are well understood. So, this would invariably call for effective communication between the requirements engineer and the stakeholders of the e-health projects. The clarity in understanding and defining problems will further facilitate in the granular analysis of the requirements which will further go a long way in developing quality e-health products [21].

Healthcare is one of the most important aspects of mankind that helps to keep the race existing on earth. Healthcare industry is one of the most information critical and process intense industries where the mankind's wellbeing is at stake. Because of this nature of criticality, the industry has been integrating with information intense advancements [22]. Information technologists have been

working towards helping the healthcare professionals to access relevant critical patient information timely, accurately, completely and reliably [23, 12].

Most healthcare gives attention for requirement engineering process according to [24], the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software. Software engineering methodology can be defined as a group of techniques and tools used in the development of software. The methodology should describe each phase of the software-development life cycle. Software methodology normally does not specify the details. These details usually left to the organization's needs and requirements. The major difference between a methodology and a framework is that a framework should be used at a more abstract level [25]. In the last two decades' healthcare applications and the use of information systems in the health, industry has grown rapidly. Healthcare is now more than simply medical care and treatment. The goal of healthcare is to provide more efficient services to enjoy a healthy society. Therefore, healthcare information system is a comprehensive, integrated and designed to manage the medical and administrative aspects of a medical organization [26]. The principal goal of IT application in healthcare is the quality improvement of medical care. Therefore, the healthcare system has to be characterized by a high reliable system. Electronic medical information systems have been identified as an enable to keep healthcare systems sustainable, reliable and safety. But to get the benefit from E-healthcare system when we developed a system based the requirements engineering and scrum agile approach.

2.3 Information Technology and Communication in Healthcare in Ethiopia

Ethiopia has a poor health status in relation to other low-income countries, even within Sub-Saharan Africa [27]. According to the ICT in healthcare of Ethiopia, the health information systems (HIS) in most developing countries are unhappily inadequate to provide the needed information support [28]. There is a need by the health sector of developing countries to use the limited resource effectively in order to provide an efficient and equitable health service to the communities. The HIS mostly used to continuing health care, maintaining health care at an optimal level, clinical and health service research, and planning and management of health systems. Information technology utilization is vital to improving patient referral system from primary care to tertiary care.

In addition to [29]the HIS refer to any system that captures, stores, manages or transmits information related to the health of individuals or the activities of organizations that work within the health sector. Overall, a well-functioning HIS is an integrated effort to collect, process, report and use health information and knowledge to influence policy and decision-making, program action, individual and public health outcomes, and research. Sound decision-making at all levels of a health system requires reliable health statistics that are disaggregated by sex, age, and socioeconomic characteristics. In the national context, Ethiopia has implemented a multisector Plan for Accelerated and Sustained Development to End Poverty (PASDEP), with specific goals related to health. The literature on the healthcare of the Government of Ethiopia (GOE) has guided all public sectors towards results-oriented management, emphasizing evidence-based decision making directed towards performance improvement. GOE has introduced Strategic Planning and Management (SPM) tools at all levels and recommended the use of Business Process Reengineering (BPR) to streamline operations. In accord with these principles and practices the Federal Ministry of Health (FMOH) has integrated SPM into its procedures and is re-engineering the Ministry itself using BPR methodology. FMOH bases its activities on the implementation framework of the Health Sector Development Program (HSDP), which has had three successive strategic plans. Each of these plans has identified strengthening Monitoring and Evaluation / Health Management Information System (HMIS/M&E) as a key strategy for successful implementation. In the [12] HMIS/M&E has not used information and communications technology (ICT) systematically to support data collection, transmission, analysis, or presentation. The introduction of ICT, and an electronic HMIS at woreda/sub city, regional/zonal, and federal levels, will considerably enhance the MOH's ability to transfer data quickly, accurately, and efficiently. In addition, use of ICT expands the range of data presentation and analysis options enormously. Given the current fragility of infrastructure and ICT support in peripheral areas, the HMIS/M&E system will first prove itself as a clean and reliable manual system that can be used as a fallback in case of ICT failures.

The great problem in healthcare of Ethiopia or ministry of healthcare of Ethiopia is that there is no the HIS assessment finding showed that computer availability is adequate and availability of basic communication infrastructure is highly adequate. Lack of integrated ICT infrastructures for HIS, limited use of available computers for health information purpose within the health sector, and

limited access to the internet at sub-national level is noted. There is no strong support system for Information Communication Technology (ICT) equipment maintenance [30].

There is a shortage of skilled human resource for HIS, the professional mix is poor and the attrition rate is very high in the health sector. In general, the human resources capacity in core health information sciences to meet health information needs is limited [30].

FMoH is implementing different Information and Communication Technology (ICT) projects to support the health care systems and most projects are at pilot levels. The current projects which are implemented by FMoH are Tele-Education, electronic-learning, Human Resource Information system (HRIS), Health Integrated Financial Information System (HIFIS), and SmartCare Ethiopia [31]. Most of the develop systems are not based on the requirement engineering process in the Ethiopia. Even those systems have solved the different problem at the different level of a sector of the organization of the healthcare. There is no enough way of a gathering of the requirement for one project in such systems.

In Ethiopia, the ministry of health puts utmost importance to strengthening the health information system of which the routine health management information system is an integral part. The government has adopted a strategy and plan of Ethiopia which makes HMIS as the core information system providing the essential information for health system monitoring. It is important to understand that the agile method is a collective name of several different methods for developing software. As we saw the importance of ICT in E-healthcare of Ethiopia and we define a scrum agile model which used to gathered an efficient requirement to implement the healthcare with high quality and increase the satisfaction stakeholders.

2.4. Role of Requirement Engineering Process in Healthcare of Ethiopia

Without the requirement engineering process, there is no understanding the requirement specification for development of software and increasing the needs of the stakeholders in different kinds of organization and increase their business based vendor of the product, especially in a healthcare organization. In Ethiopia, the requirement engineering process is not taken care of it because most of the system are developed without considering the requirement engineering process in the past year. So, the new software development is based the requirement engineering process which improves the quality of IT projects and cost-effective solution to the software problems in healthcare of Ethiopia or E-healthcare

As we review the above literature mentioned by different authors the requirement engineering process is very curial for developing the healthcare information system. To improve the quality of the existing system by integration different requirement and use to develop good requirement engineering model for E-healthcare system which used to give clear medical and manage the medical organization according to the policies of the country. So, we must give attention for the requirement engineering process to improve the quality of E-healthcare in different healthcare sectors of Ethiopia, but in Ethiopia, there is such trend for several past years. Now a day we focus on the requirement engineering process and the rigorous approach to developing the healthcare system which used to increase the quality of service delivery of healthcare and keep the security and privacy of the individual patient and stakeholders through developing the system. To increase the satisfaction of stakeholder and their expectation from the system and increase their participation in the requirement gathering through the rigorous approach of requirement modeling. Modeling represents the step that bridges the gap between analysis and design through providing formal visual representations for the system. A model is considered a good one if it is unambiguous, complete, precise, and can be easily communicated with all of the involved stakeholders [32].

2.5. Requirement Engineering Approach Model

We have elaborated them to make a comparison between agile RE and traditional RE [33].

2.5.1. Traditional Requirements Engineering Model

In the traditional requirements engineering process is a process oriented approach which is suitable for the large size of any software development project. It also needs the huge documentation and no involvement of the stakeholders in the development process. Traditional methodologies are plan driven in which work begins with the elicitation and documentation of a complete set of requirements, followed by architectural and high-level design development and inspection.

Due to these heavy aspects, this methodology became to be known as a heavyweight. Some practitioners found this process-centric view to software development frustrating and pose difficulties when change rates are still relatively low. As a result, several consultants have independently developed methodologies and practices to embrace and respond to the inevitable change they were experiencing [17, 20]. These methodologies and practices are based on iterative enhancements, a technique that was introduced in [17] and that has become known as agile

methodologies. For the heavyweight method, we reviewed several methods such as waterfall, unified process, and spiral. Heavyweight methodologies are considered to be the traditional way of developing software. According to these methodologies are based on a sequential series of steps, such as requirements definition, solution building, testing, and deployment. Most of the heavyweight methodologies require defining and documenting a stable set of requirements at the beginning of a project. There are many different heavyweight methodologies but, we would limit our discussion to the three most significant methodologies [33]. Traditional system development approaches are typically based on a more rigid waterfall model development approach, which is more inflexible and delivers the product at the end of the project [34]. There are several kinds of traditional requirement engineering model among these: the researcher classified the traditional requirement engineering process based on the size of project and type of requirement (requirement may classify as innovation and lean requirement).

A. Linear Requirements Engineering Process Model (waterfall)

The linear requirements engineering process model was proposed by Linda Macaulay in 1996. There are five activities arranged sequentially in this model namely concept, problem analysis, feasibility and choice of options, analysis and modeling and requirement documentation. This is a simple model and mostly used for small projects with some less amount of complexity but this model is not good for some large and huge projects to get their requirements. According to [35]. The waterfall model is where all the activities of the project are defined and executed in the linear sequential process. The activities of this model are the as shown in the figure 2.3 shown below the waterfall model is the most popular requirement engineering model which used to manage the huge project and complex product with the fixed or constant requirement and without user participation in different software development phase but the user participate during elicitation process or during collection of data. As work with waterfall model, there is never turning back once an activity is completed and refinement of the first model: only a few iterations are allowed which is costly to overcome such problem we must work with existing problems are left for later resolution, programmed around.

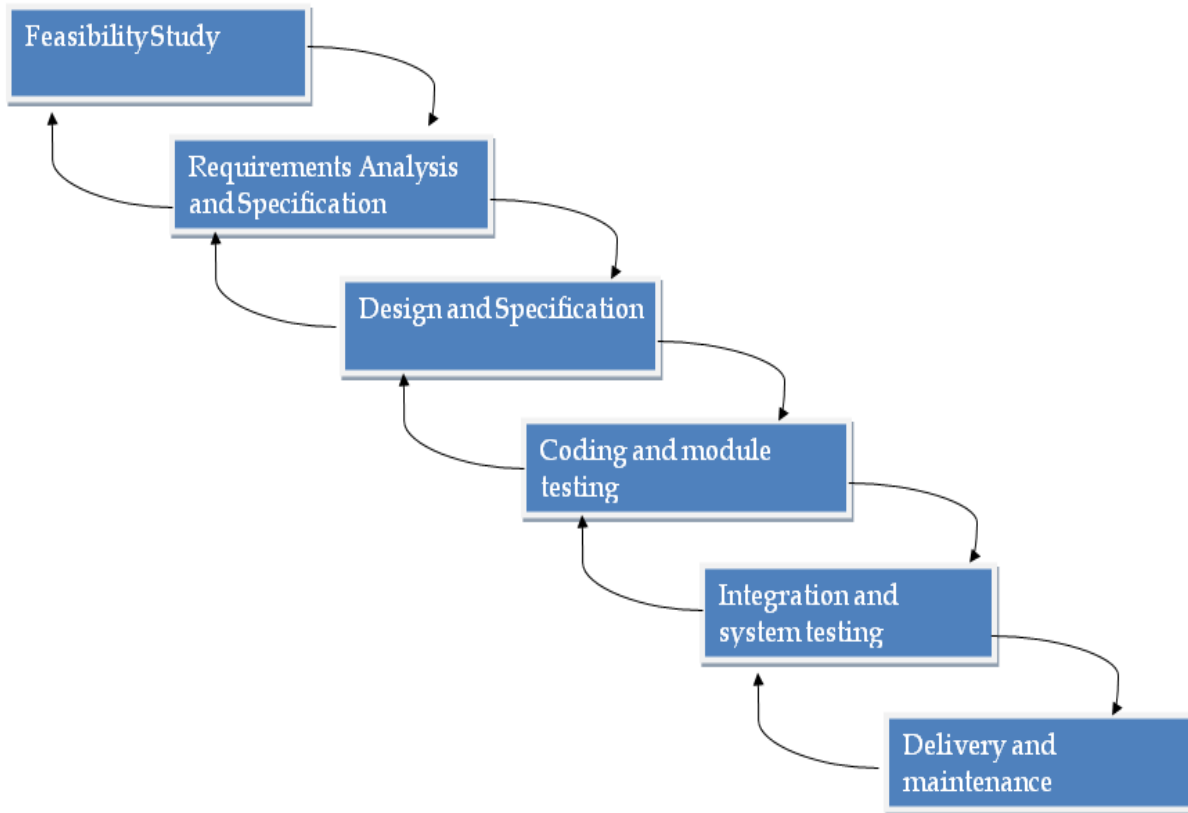


Figure 2.3.: The Waterfall Model of Software Development [35]

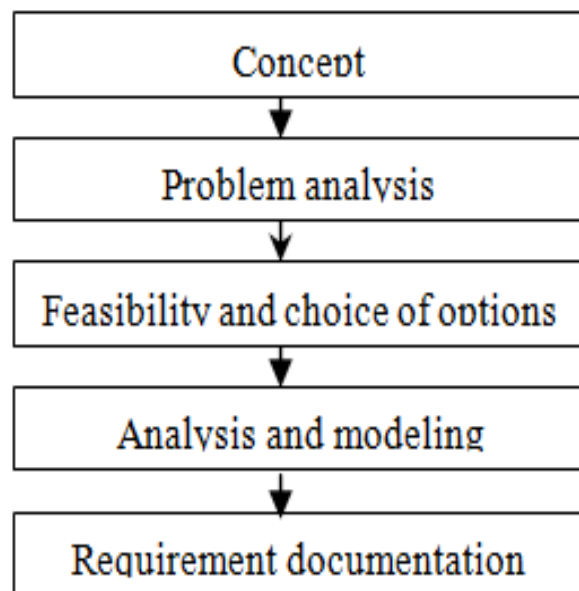


Figure 2.4. Linear Requirements Engineering Model [36]

B. Spiral Model

Another heavyweight software development model is the spiral model, which combines elements of both design and prototyping-in-stages, in an effort to combine advantages of top-down and bottom-up concepts. The spiral model was defined by [17], based on experience with various refinements of the waterfall model as applied to large software projects [17]. Most of the time spiral model is similar to the incremental model, with more emphases placed on risk analysis. The spiral model has four phases: Planning, Risk Analysis, Engineering, and Evaluation. A software project repeatedly passes through these phases in iterations (called Spirals in this model). The baseline spiral, starting in the planning phase, requirements are gathered and risk is assessed. Each subsequent spiral build on the baseline spiral. Requirements are gathered during the planning phase. In the risk analysis phase, a process is undertaken to identify risk and alternate solutions. A prototype is produced at the end of the risk analysis phase. The software is produced in the engineering phase, along with testing at the end of the phase. The evaluation phase allows the customer to evaluate the output of the project to date before the project continues to the next spiral [17].

2.5.2. Agile Software Development (Agile Approach)

ASD is a group of software development methods based on incremental and iterative development. According to the agile manifesto [37], ASD is defined in terms of values, principles, and practices. Unlike traditional development methods, agile development does not encourage upfront detailed planning for the entire project and promotes both quick clean delivery and stakeholders' involvement in the entire process of development [38].

Agile development encompasses six main methods, where they all share the core values and principles plus some common practices such as on-site customer, short iterations, and frequent releases, prioritization based on features delivering the highest business value for the customer, simple design, and peer reviews. Intuitively, each method defines its own practices based on the vision of that method. Next, these methods will be briefly addressed.

1. Scrum

Scrum is an iterative, incremental process for developing any product or managing any work. Scrum concentrates on how the team members should function in order to produce the system

flexibility in a constantly changing environment. At the end of every iteration, it produces a potential set of functionality. The term ‘scrum’ originated from a strategy in the game of rugby where it denotes “getting an out-of-play ball back into the game” with teamwork [39]. Scrum does not require or provide any specific software development methods/practices to be used. Instead, it requires certain management practices and tools in different phases of Scrum to avoid the chaos by unpredictability and complexity [40]

It focuses on management in situations where it is difficult to plan ahead. The features to be implemented in the system are listed in the backlog, where the product owner (the voice of the customer) decides which of these items are to be developed in each sprint (iteration); the development team, then, self-organizes and coordinates their work through various practices such as daily scrums and sprint planning. The Scrum method is greatly supported by a Scrum Master, who makes sure that the process is followed and there are no obstacles hindering the team from working effectively [41].

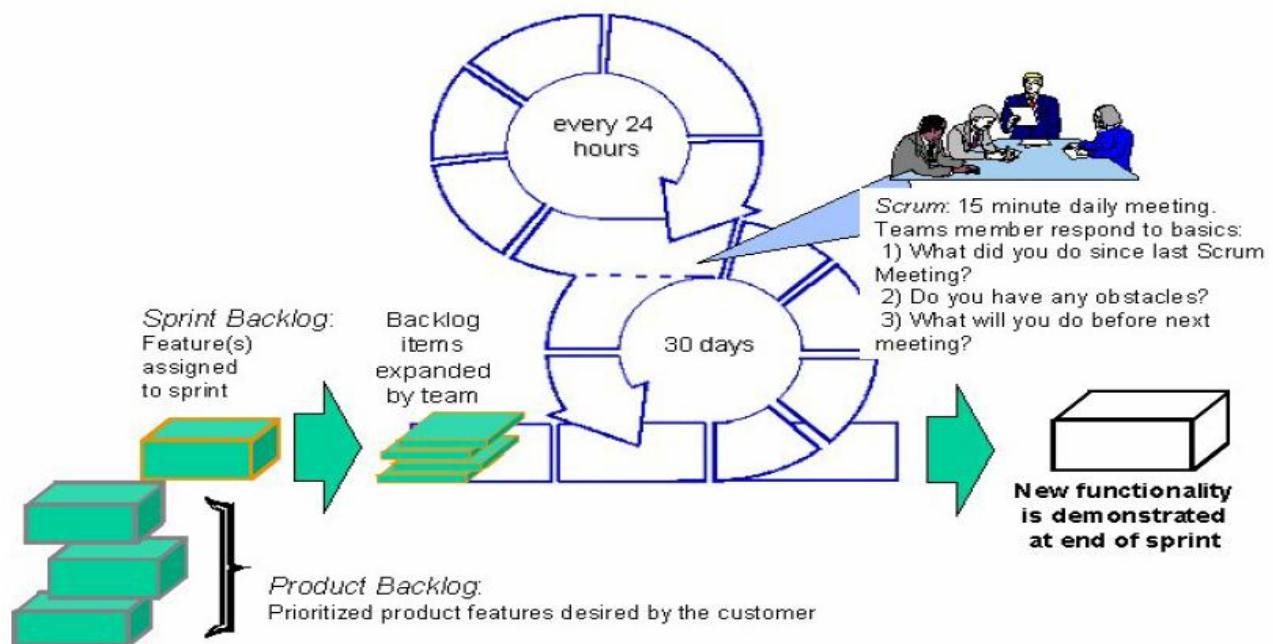


Figure 2.5. Scrum Process [41]

The key practice of scrum process:

- **Product Backlog** - This is the prioritized list of all features and changes that have yet to be made to the system desired by multiple actors, such as customers, marketing and sales and project team. The Product Owner is responsible for maintaining the Product Backlog.
- **Sprints** - Sprints are 30-days in length, it is the procedure of adapting to the changing environmental variables (requirements, time, resources, knowledge, technology etc) and must result in a potentially shippable increment of software. The working tools of the team are Sprint Planning Meetings, Sprint Backlog, and Daily Scrum meetings.
- **Sprint planning meeting** – Sprint planning meeting is first attended by the customers, users, management, Product owner and Scrum Team where a set of goals and functionality are decided on. Next, the Scrum Master and the Scrum Team focus on how the product is implemented during the Sprint.
- **Sprint Backlog** – It is the list of features that is currently assigned to a particular Sprint. When all the features are completed a new iteration of the system is delivered.
- **Daily Scrum** – It is a daily meeting for approximately 15 minutes, which are organized to keep track of the progress of the Scrum Team and address any obstacles faced by the team.

Many other models like the Crystal Methods, Adaptive software development, Feature Driven Development; Dynamic Systems Development Methods have evolved over the last two decades which follow the similar iterative processes.

2. **Extreme Programming (XP; XP2)**

Extreme Programming believes in implementing the best practices of software development. XP adopts 12 practices, which are: simple design, test-driven development, refactoring, pair programming, small releases, metaphor, collective code ownership, planning game, continuous integration, on-site customers, 40-h week, and coding standards. The revised version of XP is called XP2 and it adopts similar practices to these of XP with slight variations such as quarterly cycle, weekly cycle, and 10-minute build [42].

3. **Feature-Driven Development (FDD)**

FDD is a short-iteration process that focuses on the development of critical systems, where an iteration of a feature consists of both design and building. FDD is a blend of model-driven and agile development with the assertion on object models, a division of work in features, and iterative design for each feature [43]. Feature Driven Development (FDD) was used for the first time in the

development of a large and complex banking application project in the late 90's [43]. Unlike the other methodologies, the FDD approach does not cover the entire software development process but rather focuses on the design and building phases [43].

4. Dynamic Systems Development Method (DSDM)

DSDM is a rapid application development framework that consists of 3 phases: (1) pre-project (for the feasibility study); (2) project life-cycle (for the business study); and (3) post-project (for the development). DSDM adopts 9 main principles: empowering the project team, iterative and incremental development, testing throughout the development lifecycle, frequent delivery, efficient and effective communication, user involvement, addressing current business needs, allowing reversing changes, and high-level scope being fixed before project starts [44]

It was developed in the United Kingdom in the mid-1990. It is a blend of, and extension to, rapid application development and Iterative development practices [45].

5. Adaptive Software Development

Provides a framework, with enough guidance, to save large and complex projects from falling into chaos; it strongly encourages incremental iterative development with constant prototyping. Adaptive software development consists of three phases: (1) speculation (recognizing the uncertain nature of complex problems and encouraging exploration and experimentation); (2) collaboration (working jointly to produce results, share knowledge, or make decisions); and (3) learning (acknowledging failure and positively reacts to mistakes). The principles of this method are: mission focused, feature based, iterative, time-boxed, risk driven, and change tolerant [46]. It was discovered by James A. Highsmith, offers an agile and adaptive approach to high-speed and high-change software projects [47]. It is not possible to plan successfully in a fast moving and unpredictable business environment. In ASD, the static plan-design life cycle is replaced by a dynamic speculate-collaborate-learn life cycle.

2.6. Requirement Engineering Agile Approach in Healthcare

In e-health environments with numerous, scattered stakeholders, such as patients, individuals, professionals and organizations, e-health goals and values may vary and conflict with one another depending on stakeholder's perspectives of the environment in which these goals are being used and the services they aim to acquire [7]. Most of the requirements engineering is a solution to

deploy e-health technological innovations, to facilitate the successful provision of healthcare services

RE process in agile projects is diverse to the traditional software development projects. The accommodation and adoption of rapid changes in stakeholder requirements and preferences, competitive environments, market pressures, development technologies are the important aspects of agile software projects. In many agile projects, the development starts without the formal requirements analysis and design phase. The requirements evolve and mature through continuous feedback from the customer throughout the development of the project. Agile methodologies like XP and Scrum advocate that RE process is carried out throughout the life cycle of the project for every small iteration/stage.

2.7. Comparison of the Requirement Engineering Approach in E-Healthcare

As we review different research paper the researcher was used different requirement engineering process approach model to give a solution to particular problems. Most of the researcher choose the agile requirement engineering approach model rather than the traditional one because there is a dynamical change of requirement throughout the development projects and to fulfillment of stakeholder needs, software engineering the most challenged during the gathering of requirement using different approach to solving the exact problem that raises from the users and the clients. We try to mention the most popular two kinds of requirement engineering approach model: the traditional approach and agile approach. Due to the absence of customers and users, traditional requirements elicitation techniques relying on user or customer intervention are usually inappropriate.

When we develop the huge and complex project with fixed requirement and once we fixed the requirement during the elicitation phase of software development life cycle then no interaction with developing a situation of the system from the perspective of the end users.

We summarize by this table that tells us the difference between both requirements engineering approach.

Table 2.1. Comparison of Requirement Engineering Approach

<i>Traditional Approach</i>	<i>Agile Approach</i>
Requirement engineering process takes place in the first start of the project only once prior. Change: any change of requirements is not present afterward.	✓ RE process is an expected process in agile which point from start to end of the product. ✓ Any change of the requirements is present afterward.
Focus on: predictive and process oriented development.	✓ Adaptive and people oriented
Modeling approaches present by: ➤ Data flow diagram (DFD) which show the process of data. ➤ Entity relationship diagram (ERD) and Statechart describe the conceptual of representation of requirements of software and show the behavior of the system respectively.	✓ An iterative and incremental model which show the progress of the system. ✓ Capability maturity model describe the quality of the requirement ✓ Process maturity model which show that the adaptive of requirement change
Management: through huge documented and which used to reduce the overall risk.	✓ No proper documentation
User involvement: no user participates as the whole process of the developing project	✓ User participate
Project and team size: large	✓ Small
Time and cost effective: time-consuming and large budget asked	✓ No time consuming and not asked large budget
Examples of tradition model: Waterfall, Spiral, Rational unified process, etc.	✓ XP, Scrum, Feature Driven Development, DSDM etc.

But in recent, the requirement must be changed according to user needs and user participate in the development software for a particular problem. A core problem in most e-health projects is that they are highly technology driven, and the issue of eliminating ambiguity and closing the gap between stakeholders and software developers has never been addressed.

Scrum approach is the most flexible and more efficient rather than agile approach used to the management of the developing projects. So, every healthcare organization used scrum approach to control their project for improving the efficiency and quality of service delivery to the stakeholders.

As a software system, E-health exists to fulfill the goals of different stakeholders, such as society, patients, professionals, health organizations, and governments. These goals can significantly help the requirements engineering phase.

Most of the healthcare system of Ethiopia is not develop through gathering requirement using different approach even if the traditional approach, but to improve the quality of service and reduce the costing software we must be focus requirement engineering using the most flexible and efficient requirement engineering approach model. Due to the requirement engineering process the project may success or fail and no customer satisfaction with the system.

Currently in Ethiopia give attention to the requirement engineering process which used to develop the District Healthcare Information system (DHIS). It is the new proposed projects and stakeholder participate on the project through gathering the requirement. The new proposed DHIS project is to increase the quality of healthcare service delivery and satisfy the end user or stakeholder of this project.

2.7. Related Work

According to Bu et al. [48] Health information systems have demonstrated positive outcomes in improving care for chronically ill patients. Show that information technology enabled diabetes management has the potential to improve care processes, delay diabetic complications and save healthcare dollar.

According to their opinion, healthcare information system shows that how to increase the quality of the system and improve the satisfaction of the stakeholders. They tried to show us requirements engineering process for continues assessment improvement of healthcare IT projects. Moreover, they used traditional requirement engineering approach. But now a day it is difficult to use traditional requirement engineering because the technology and business idea are change

throughout the time. To address the problem of requirement changeable and to manage the change of requirement they didn't the proper management mechanism.

Boehm [20] investigated the cost to fix errors in the development of large software systems. Most of the projects followed a fairly standard sequence of phases: requirements analysis, design, coding (programming), development testing, acceptance testing, and operation. A requirements error not found until after delivery will cost a hundred times more to fix. According to Boehm, the longer a problem goes unnoticed, the more subsequent design decisions are based on it, and hence the more work it will take to unpick them. He also has been suggested that cost of requirement change increases exponentially with the progress of the project. He states the requirement engineering process in a different organization that solves the different problem which happens to get the appropriate requirement development software. He enhances the quality of the software development life cycle. He mentions different traditional requirement engineering approach with fixed requirements. But now a day the innovation of technology and business idea are changed. He also mentions different kinds of model evaluation criteria which increase the quality of development software. Those are correctness, completeness, consistency and availability of the requirements. The model that he proposed has the traditional requirement engineering process phase.

Damian et al. [49] Explored the impact of RE on software development processes. They have found that testing has positive effects by improving RE and the involvement in terms of increased testing involvement in requirement engineering activities. They show the impact of requirements engineering process, emphasize that the requirement engineering is which determine the functionality of any system. By increasing the quality of requirements, they improve the quality of software development process. They also mentioned different requirement engineering activities and they show how to use those activities in software development process. These requirements engineering activities are such as requirement elicitation, negotiation, and analysis, validation and documentation. They used the proper approach which solves that they want to address on requirement elicitation (gathering requirements for the systems are identify the feasible of the problem and direct the solution) and they point out conflict the need of stakeholder and analysis the requirement that gathers from the stakeholder. They also verify the requirement and agree to the requirement in the desired database.

Barry Boehm disagrees to a degree with the first principle of the agile manifesto which states, “Our highest priority is to satisfy the customer through the early and continuous delivery of valuable software” [50]. He states that “Over focus on early results in large systems can lead to a major rework when the architecture doesn’t scale up” [20]. He used the methodology of software development life cycle is traditional requirement engineering method rather than agile. According to his suggestion the project and team size factors to use the manifesto agile method. With this scenario, large project and team size proper documented of the requirement which affects the user communication throughout the developing process. In traditional requirement engineering, the priority of the requirements of any system determines in term of the cost and time valuable. Most of the time the traditional requirement engineering methodology which used to develop the architecture of any project is Rational Unified Process. Even if he proposed such method didn’t scale the architecture of the system. Because of he disagreed with the manifesto agile method he lost the advantage of the agile method that has over traditional.

Even the originator of agile modeling Scott Ambler mentions, he would be doubtful of applying agile modeling to life-critical systems. Heavyweight traditional goals such as predictability, repeatability, and optimization are often characteristics of reliable safety critical software development. Most agile techniques do not support traditional walkthroughs and code inspections during the life-cycle, it emphasizes on pair programming and informal reviews as their quality control mechanism. The author suggested the technique of traditional requirement engineering develop the critical software which not support in agile. In this scenario, the elicitation of the requirement ended early at the project plan in the traditional method. The emphasis that the change of requirements is tolerated. He also tried to user participate in developing process and the proper documented of the requirements. But the researcher rather shows us the technique agile not support the traditional method it is better how to use integrate of the technique both approach.

McGee-Lennon in [51] suggests features which should be provided by requirements engineering approaches in the home care requirements elicitation and analysis. However, the researcher addresses the problem of requirement engineering process in home healthcare system development. He also tried to show the user involvement in developing process and address the gap between stakeholders needs with expected system function. He proposed the new approach which identifies the appropriate requirement gathering mechanism. He used the agile approach to

gathering and analysis the requirement engineering that development home healthcare system. In agile requirement engineering approach is used to the enhancement of the home healthcare system. But the researcher doesn't put all the phase of software development life cycle. Thus, caused the additional cost of requirement validation and documentation in the system. Most of the researcher works with requirement engineering to enhance the information technology in a different organization to increase their business innovation and increase the value of organization make more profitable and keep the security and the privacy of the user, healthcare one of the most organization that at all time information is processed. Almost the researcher on the above-related work, they didn't define the gathering requirement and put clear enough requirement to the development of software in healthcare. To put enough requirement and elicited the requirement for development the software system. The related works show us the way development of software in a different organization using different requirements engineering approach. The requirement engineering approach decides by the size projects and a team of developing process. The traditional requirements engineering process are perfect in a document of the requirements and use large project size.

Additionally, the researcher identifies the requirement engineering process how to use in E-healthcare projects. Thus, if the requirements engineering is wrong the project may late, asked additional cost than estimate the original cost and the stakeholders need no met or fulfill the requirement. Now a day most researcher works with an agile methodology to the development of software how to apply in adaptive of the system. The agile requirement engineering methodology the way of best practice adaptive in software development life cycle. The agile more advantage than another approach (traditional requirement engineering methodology) in that it is user involvement in developing a process of any software i.e. used to get clear requirements from stakeholder and face to face communication with developers. In this scenario, it increases the quality of software and met the goal of organization vision.

This related work summarizes as follow.

Table 2.2.: Table of related works

No	Author Name	Proposed Solution	Reference
1.	McGee-Lennon	Provided by requirements engineering approaches in the home care requirements elicitation and analysis. He also states that the elicitation of health care requirements should be an interactive process. The requirement is must be balancing and validating.	[7]
2.	Martin Fowler	He mentions that agile methods provide workable solutions only for “business software”. He also provides for determining RE, you assess the probability of loss, $P(L)$, involved in a course of action, the the corresponding size of the loss, $S(L)$, and then compute the risk exposure as the expected loss: $RE = P(L) * S(L)$	[51]
3.	Barry Boehm	His suggestion that most agile techniques do not support traditional walkthroughs and code inspections during the life-cycle and investigated the cost to fix errors in the development of large software systems	[20]
4.	Damian	He explored the impact of RE on software development processes. He also found that testing has positive effects by improving RE and the involvement in terms of increased testing involvement in requirement engineering activities.	[49], [48]
5.	Kathleen Wyne	He states “integrated diabetes management system. This proposed system would allow providers to make effective decisions both at the point of care and across the entire diabetic population, as well as empower patients to actively participate in those provider decisions	[52]
6.	Scott Ambler	“He would be leery of applying agile modeling to life-critical systems”.	[48]

To address the gap of requirement engineering process used to develop a software, using different requirement engineering approach. But we identified the problem of using agile approach in healthcare IT project. Most researchers investigate the requirement engineering process in different software industry using agile approach but not in healthcare IT projects and not used scrum agile approach in E-healthcare. So, we proposed an efficient requirement engineering process and rigorous model which improve the quality of healthcare IT projects and increase the satisfaction of the stakeholders.

Chapter Three: Research Methodology

3. Research Methodology

The research is mainly focused on the systematical methodology that used to solve the research problems and the hypothesis that raised on literature review.

3.1. Research Approach

There are different techniques, that related to the researches and background theory have been revised through literature review. Three different approaches were investigated, quantitative, qualitative and mixed. The quantitative research approach is defined as research that explains phenomena according to numerical data which are analyzed by means of mathematically based methods, especially statistics[43]. It is applicable to phenomena that can be expressed in terms of numerical [44]. The qualitative research approach is concerned with subjective assessment of attitudes, opinions and behavior and it is simplistic since it focuses on procedures and techniques used to collect and analyze data, ignoring other aspects of research design [45]. In [45]based on the epistemological assumption that social phenomena are so complex and interwoven that they cannot be reduced to isolated variables. For this research, we used mixed research approach for manipulating the data and for evaluating the functionality of prototype.

3.2. Research Design

The research design is the conceptual structure within which research would be conducted. Its function is to provide ways for the collection of relevant information and analysis within minimum expenditure of effort, time and money [53]. The research type that we used is empirical research which tests the feasibility of a solution using empirical evidence to overcome the requirement engineering process in E-healthcare projects in Ethiopia health sectors.

3.3. Method of Data collection and Techniques

Data collection methods that which we apply for this study are: observation, interview, and document analysis are used to accomplish the research. We have two data collection procedure i.e. primary data collection which includes interviewing the professionals, service providers, government body and others. Secondly, secondary data collection which questionnaire and document analysis

3.3.1. Interview

The interview is the way of direct communication with the respondent. The semi-structured interviews focus on the individual, which helped the researchers to understand the individual respondent's personal perspective around the use of projects in healthcare. Based on the interview the respondents have two side which means the project is success perspective and from stakeholder satisfaction. But based the questionnaire data collect by using question paper not direct to respondents.

3.3.2. Questionnaire

Questionnaire is the way of collecting data from respondent survey by using question paper. So we have different indicators to collect the data from respondents. We have been collected the following using both techniques.

3.3.3. Sample Data

Table 3.1: Respondents data

<i>Objective</i>	<i>Indicators</i>	<i>Numbers of Respondent in percent (100%)</i>
Healthcare IT project without RE process	fail	75.46
	successful	25.54
Impact of RE on stakeholders satisfaction crossover healthcare IT project	Satisfy	27
	Not satisfy	72.66
Have RE process direct relationship with IT project	Agree	89.88
	Disagree	10.12
Suitable SDLC to development healthcare IT project	Scrum	49.2
	RUP	14.66
	EP	15
	Waterfall	15.66
	Spiral	14.66
Requirement change tolerate on scrum approach	Yes	79.5
	No	11.5
Healthcare IT project delivery due RE	Delay	55
	Not delay	45

As we have seen in table 3.1 the healthcare IT project developed without RE and rigorous model has high failure and most stakeholders were not satisfied with existing system that developed without considering the requirement engineering and rigorous model.

3.3.4. Observation

As we observe different healthcare sectors and ministry of health of Ethiopia which they use exist system and healthcare IT software around 73 percent of healthcare IT projects are not success or some of them were a failure and the needs of stakeholders were not satisfied with the existing system.

3.3.5. Document Analysis

In Ethiopia, there is no trend of the well-documented requirement to develop a software in healthcare IT projects. That means no requirement engineering process to develop the system. Most of the document existing the developed healthcare IT projects are manual or modules which show that how to use the system. If even there is no documentation of the requirement engineering process that used to develop the software in e-healthcare of Ethiopia we review the different literature to analysis the data.

3.4.Tools and Techniques

To accomplish this research, we used Microsoft office word for preparing the document and UML tools for designing the model or the requirement engineering process phase (Edraw-Max and Microsoft Vision). The main reasons for using UML are: using standardized notation without sacrificing specialized model data, increased domain (the healthcare organization domain) design model reuse, and increased the customer involvement/ understanding of the problems translation to products solution. The prototype of this study is used how requirement elicits through online giving feedback from different users in a different district of the country. The tools we proposed to demonstrate the prototype is asp.Net with integrated visual studio programming language especially CSS because the asp.Net is compatible with running most of the web application.

Chapter Four: Proposed Solution

4. Proposed Solution

As in the previous chapter three survey from those indicators for instance failure, successes and satisfies indicates that most of the stakeholders are not satisfy within the existing system. Additionally, most developed IT project in healthcare of Ethiopia were not a success and ask additional cost to fix error durable in the developed project.

In fact, the DHIS is an open software which used to gathering information, retrieve the information, for data store and manipulate large amounts of sensitive data in a distributed setting and etc. but in Ethiopia it used to not only for such purpose it also used to make decision, plan and budget for healthcare based on the information that gathers from different district of four regions of country. DHIS is also used to increase the quality of healthcare service through the country and fair distribution the service. To develop the DHIS we must gather the requirement from the district of the selected region through the proposed model to solve the problem of requirement engineering process that happens in healthcare IT projects. The problem in healthcare IT projects are there is no an efficient requirement engineering process and there is no rigorous method which used to develop the system.

On another hand to increase the quality of requirement and to improve the communication between stakeholder and software developer, we focus on requirement engineering and the rigorous approach. As a ministry of healthcare of Ethiopia mentions to us there are no trend gathering requirements for developing the healthcare projects and again there are no stakeholder involvements in developing of the healthcare system. In the scenario, we proposed the agile (scrum) approach and we apply the requirements engineering process which increases the quality of requirement and meets the need of stakeholder. Thus, to reduce the error on gathering of requirement from different district of the country, at the time and within estimation budget of the elicited requirements.

The scrum is a flexible agile approach which we have proposed to gather an efficient requirement to develop the software with the high quality of service delivery in the healthcare. Scrum has the advantage of the stakeholders' involvement in developing a process of software, face to face

communication between stakeholders and it also the easy management of the change requirements at any stage SDLC during the elicitation of requirements.

Thus, increase the quality of requirements elicitation based this scenario we develop the software with high quality and the developed software meet with the expectation of stakeholders need so, the scrum used to improve the quality of healthcare IT projects and increase the satisfaction of stakeholder. The healthcare IT projects developed through approach has a high quality of service delivery in healthcare at the right time, at the right care cost and to the right patient. We reviewed different research [12, 7, 49, 8] papers that show to us how to use the agile approach rather than traditional one i.e. the traditional requirement engineering approach has huge team size, project size, project time. In the scenario, it is difficult to understand the requirement and there is no better communication between the stakeholders. Additionally, the traditional approach has fixed requirement for many projects. Thus, now a day the need of most stakeholders is not fixed or constant and there is the rapid growth of technology and business idea.

The proposed approach which is agile (scrum) model has four phases: requirement elicitation, analysis and design, specification and implementation, and validation and documentation. The Ministry of Health of Ethiopia doesn't develop the user participate E-healthcare system using requirement engineering process agile approach. To develop the District Healthcare Information system (DHIS), we must be giving attention to the requirement engineering process and the rigorous approach. The requirements engineering process is illustrating the conceptual process and on the proposed model. This new system developed through proposed model the stakeholder's involvement in developing a process of the project and the requirement elicitation through this model. Because of the requirement gather with quality which used to develop the project in E-healthcare improve the quality of service delivery and solve the challenges of healthcare in the country.

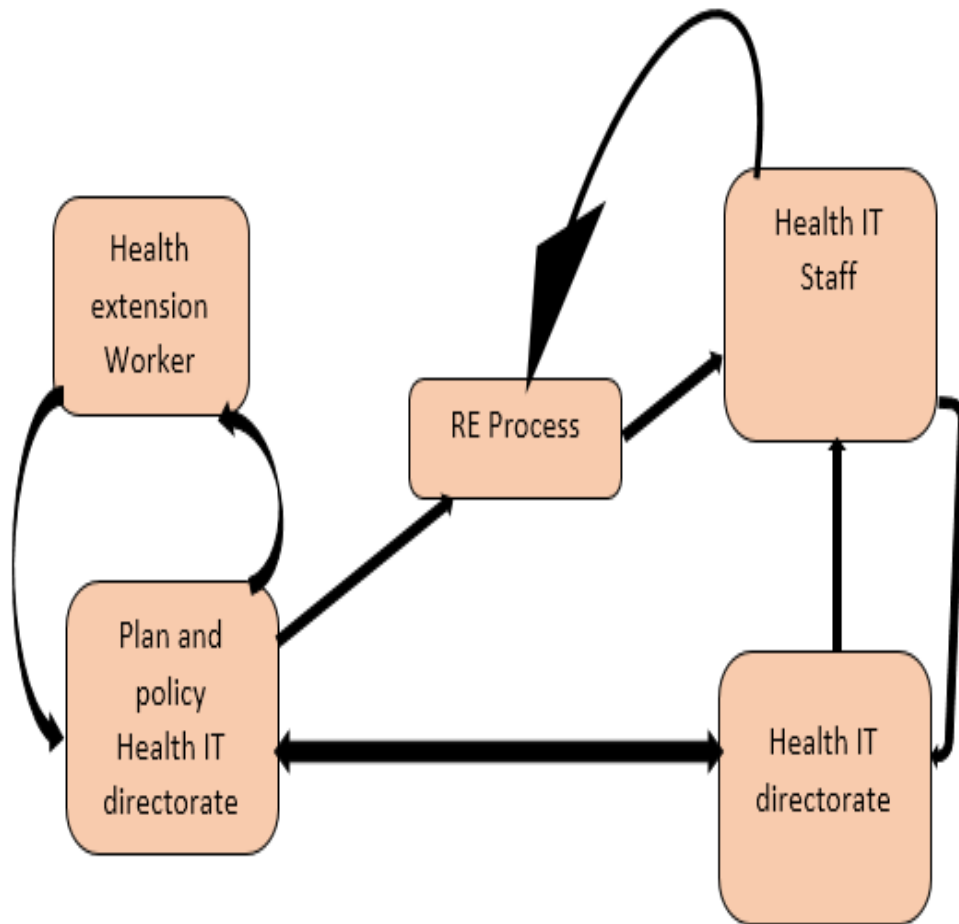


Figure 4.1. Conceptual Model of Requirement Engineering Process

In this conceptual model, we proposed iterative model integrating with the scrum agile which is an iterative and incremental method used to develop the system in healthcare. In our country, the healthcare IT projects is not find out requirements engineering process and scrum agile approach. The model that we proposed which answered the question of gathering quality requirement to develop the software in healthcare.

Additionally, the model not only answered the quality of requirements in healthcare organization sectors of the country but it used for other organization like ministry of agriculture, ministry of education and etc. this model characterized by the requirements quality evaluation criteria: correctness, completeness, consistency and availability of any requirements used to develop the projects.

As we aspect, the result of any system in healthcare an efficient and effectiveness system used to enhance the quality of service delivery to society and satisfy their need. To increase and improve the quality of the service delivery in healthcare and satisfy the need of stakeholder we apply the requirement engineering process and an iterative and incremental flexible model. We gather the requirements from the district of the country using proposed model. But the need of stakeholders is not similar and most of the stakeholders are used vague words. Thus, to fix this problem we used this proposed model.

In Ethiopia, the development of software in healthcare haven't the quality gathering requirement and model. In this scenario to gather the quality requirements and improve the quality of IT projects in healthcare, we apply scrum agile software development method with this proposed model. In the scrum, agile method there is three things or the environment. These are the product backlog (plan and police healthcare IT directorate), scrum master (healthcare IT directorate) and the sprint (healthcare IT staff). The scrum product backlog (plan and police healthcare IT directorate) used to prioritize the list of all functionality of system and change of requirements that gather from the district health sectors of the country. The product backlog (PPHITD) contain the prioritize requirements based on the value and cost of requirements and need of stakeholders (society, health extension worker, health professional, IT professional worker in healthcare, etc.) meet with the develop projects. The ministry of healthcare is responsible for maintaining the product backlog (PPHITD).

The sprint (healthcare IT staff) is meeting 2-4 weeks to implement the analyzed and designed requirements that gather from district health sectors of the country through the health extension workers. The sprint (healthcare IT staff) mostly to used sharing requirements, resource, knowledge, and technology. It has the team management which used to manage and control the implementing process of the project.

The scrum master (healthcare IT directorate) is mainly focused on the management or control of change of requirements throughout of the development of healthcare IT projects. The management of requirement may be validating and verify the requirement using different techniques. Validate and verify the requirements are the need of stakeholders are meet with the expected functionality of the system. In the scenario, which increases the quality of requirements and improves the satisfaction of stakeholders. It also used to store validate and verify requirements into a database

which help to develop another healthcare IT projects in the country. In scrum, agile software development method, the requirements have great quality because we apply requirements engineering process and the involvement of stakeholders in developing process. This way keeps the track of software quality and the successful of project and delivery on the time need. It also improves the way gather or elicit an efficient requirement to develop the system.

Ethiopia the country ongoing developing and made the transformation police to success the goal of healthcare vision. To address the gap between the developed projects in healthcare and needs of stakeholders we must apply the requirement engineering process and agile software development method through proposed model. Thus, help to increase the quality of service delivery and improve the satisfaction of stakeholders. In this conceptual model, the target used to analysis the requirements are the health extension worker, plan and police healthcare IT directorate, healthcare IT staff and healthcare IT directorate. It also shows that the process of requirement engineering which helps to develop the DHIS in healthcare of Ethiopia.

The proposed solution is solving the problem raised in the requirements engineering process in healthcare IT projects of Ethiopia. This proposed solution aims to answer the problem how to gather or elicit the quality requirements for developing the healthcare IT projects and meet the needs of stakeholder within the expected solution. We gather data from the ministry of healthcare of Ethiopian then we motivate to develop a model which help to us apply requirements engineering process in healthcare.

When we consider the requirement engineering activities like requirements elicitation, requirement analysis, and design to implement the system, specification/implementation, requirement validation and documentation. Those activities controlled by the requirements engineering process. Because of there are trends of requirements engineering process and any approach to healthcare IT projects in Ethiopia we motivated to develop the actual model. This actual model is called integration model in figure 4.2 below show us the iterative and incremental process to develop the project based on the healthcare policy of the country.

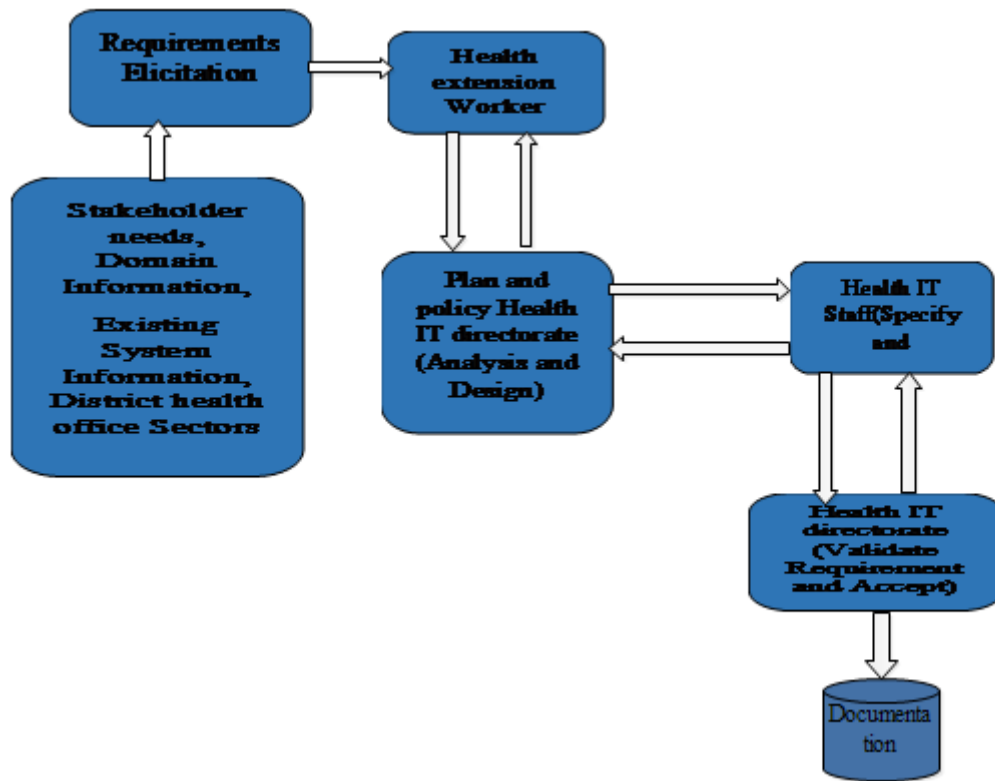


Figure 4.2: Proposed Model

4.1. Requirements Elicitation

Requirement Elicitation is the process through which analysts determine the software requirements of stakeholders. It also the process of seeking, capturing and consolidating requirements from available requirements sources. It is also the main task of understanding the environment and the software situation [54]. It is gathered through the health extension worker from the district of the selected region of the country. In [12] an important part of requirements gathering is obtaining requirements from people: requirements elicitation. Without an accurate understanding of what the stakeholders really want and need, projects cannot develop what the stakeholder's desire.

One of the primary goals of Agile when gathering requirements is to provide organizations with flexibility and a more efficient use of their budgets.

The requirement mostly depends upon the plan and policy of health IT professionals. The elicitation of the requirement is most of the time is efficient to develop the system because the

elicitation system is simple and didn't make an error at the time of gathered. The health extension worker gives the feedback or the requirement to the healthcare plan and police IT directorate and access the progress of the project. The health extension worker gathers the requirements from district by using the REF.

Most of the time requirement elicitation is distinguish the feasibility of requirements in terms of economy, technology, time need and social. Based on the proposed model (integration requirement engineering) the requirement elicitation interacts through health extension worker. To gather an efficient requirement, we using the model that we proposed emphasize the requirement determine the project look like and the scope projects and it stores as a product backlog. The methodology that we proposed which explain and the exact solution to the problem with requirements in the healthcare IT projects is requirements engineering techniques that can be efficiently and effectively used to gather requirements in an agile development process. Agile application development is extremely flexible, therefore traditional requirements engineering techniques need to be chosen carefully and should be modified slightly in order to adapt to the agile development process. Here, some of these techniques and approaches that can be helpful for gathering requirements in agile environments have been discussed [12].

4.2. Analysis and Design

During this activity, the requirements are analyzed in order to be fully understood as well as complemented with additional information [55]. The requirement is analyzed and designed by the health plan and police IT directorate based on the requirement that takes from the health extension worker. In phase, the plan and police released then the requirements are gathered from health extension worker as a checklist. And health plan and police IT directorate analysis and design the requirement pass to the health IT staff to success the project on time and within a given budget.

Analysis the requirement is the way of verifying the requirement with the need of stakeholder meeting to implement the project. The analysis also determines the scope of the project and designed the system functionality based on the distinguished requirements. The plan and police healthcare IT directorate gives attention to requirements engineering process to analysis the requirements that gather through health extension worker and to take the right decision to development projects. The plan and police healthcare IT directorate interact with the health extension worker and healthcare IT staff through the proposed model to accomplish the

development of the project. The plan and police healthcare IT directorate work as product backlog of scrum approach which helps to prioritize the requirements.

Prioritize of the requirement is avoid the ambiguity on the elicitation requirement. In the plan and police healthcare, IT directorate requirements are store as some task of the projects. When customer expectations are high and timelines are short, you need to make sure that the product delivers the most valuable functionality as early as possible and its functions under the pressure and limitation.

After analyzed of the requirement is finished then the design of the requirements is started. The design of requirements is used to assess the correctness, completeness, and consistency and the plan and police healthcare IT directorate send the designed requirement to healthcare IT staff to implement the projects in form of document then the implementation is accomplished the requirements are stored in the database.

4.3. Requirement Specification / Implementation

The healthcare IT staff point out the requirement specification to implement the system. This phase the stage of requirements is specified as of needs of stakeholders which used to support the efficiency of system requirement and increase the satisfaction of stakeholders. Requirements are modeled to make it more clearly for the developers. Models make requirements easy to understand. During the requirements specification, great task is verifying the system requirement with stakeholder needs.

In our proposed model the healthcare, IT staff implement the system and send the specified requirement forward and backward to the healthcare IT directorate and healthcare plan and police IT directorate respectively. Thus, the healthcare IT staff send feedback to healthcare plan and police IT directorate to clarify the ambiguity on design requirements. This is the process how to improve the quality of system service and increase the satisfaction of stakeholders.

In Ethiopia, there is no trend how to specify the requirement and rigorous approach to developing IT projects in healthcare. Which caused the projects failures and no satisfaction with development software in the sectors. Now a day we proposed a rigorous approach which helps to specify the requirements to develop the projects.

The requirement specification the quality of system functionality and improve the performance of service delivery in healthcare sectors.

Since we develop a rigorous approach which increases the requirement and improves the satisfaction of the stakeholder. In healthcare of Ethiopia there is a gap requirement engineering process, to address this gap we proposed an efficient requirement engineering process through scrum agile approach.

4.4.Validation and Documentation

The final phase of the proposed model that describe how to validate the requirements and illustrate to documented for implement the system. The HITD manage the requirements are verification using the proposed model. The requirements are validated by some criteria that stated most requirement engineering process [8]. These are completeness, consistency, feasibility and verifiability. The model that we proposed suitable for validating the requirement using the requirement validation criteria. Why we use requirement validate to overcome the problem of it is difficult fixed error after the system developed were delivery and increase the cost of maintenance.

The HITD validate requirement to cover the problem of requirement adaptability, technology adaptation, and stakeholder constraint. So, we proposed a scrum agile model to this problem in validation section for healthcare in Ethiopia. In Ethiopia, most IT projects developed in healthcare were not used proper requirement engineering process and rigorous approach. We illustrate the validation of requirement through developed prototype. There are three kinds of requirement validation techniques [56] i.e. review, prototype and test case generation.

The requirement validation techniques which increase the quality of requirements and gather requirement meet with stakeholder needs. In this scenario, the requirements are clear defined and well documented used to requirement review mostly to identify the system requirement to implement and involve stakeholder in requirements review manually but we develop a model scrum agile requirement engineering process which using prototype used to avoid an error on requirements. Finally, after the HITD accepted or agreed on validate requirement then the requirements documentation is taking place. Requirements documentation may take many forms, including spreadsheets, diagrams, and text. The requirements documented in the database which shows on proposed model used to solve the well-organized of the requirement to develop IT project in healthcare. Documents defining requirements in simple language, or use cases where particular scenarios are defined together with required outcomes for each scenario. Measures of success include the ability for each key stakeholder needs and business decision-maker, developer, and

quality assurance tester to have a common understanding of the expected functionality based on documentation content [30].

4.5.Integration of the IT Project and Scrum

In IT project, RE activities were once the requirement specify to develop any project no required requirement change at any stage of SDLC. But it is important for develop huge project with fixed requirement while now a day the business idea and technology are rapidly growth. So, it is difficult develop project with fixed requirement. The scrum agile solve the problem of fixed requirement and user participate in developing project. Thus, to increase the quality of requirement and improve the efficient of software development we follow scrum requirement engineering approach. The requirement gathers through product backlog which increase the stakeholder involvement in development software and increase the understanding the need of stakeholders. Any IT project has five phase requirement engineering activities: requirement elicitation, analysis and negotiation, validation, documentation and management. The scrum agile has three main things product backlog, sprint and scrum master. The arrow bidirectional show that the RE activities were done at that phase of the model. So, we proposed a model which has the benefit of scrum approach and RE process in healthcare IT project.

Table 4.1: Integration Model

<i>RE activities</i>	<i>Scrum activities</i>	<i>Proposed model activities</i>
Requirement Elicitation	Product Backlog1: Requirement elicitation	Requirement Elicitation
Analysis and Negotiation	Product Backlog2	Analysis and Design
Validation	Scrum Master	Validation and Documentation
Documentation	sprint	Specification/implementation
management	Scrum master	Health IT directorate

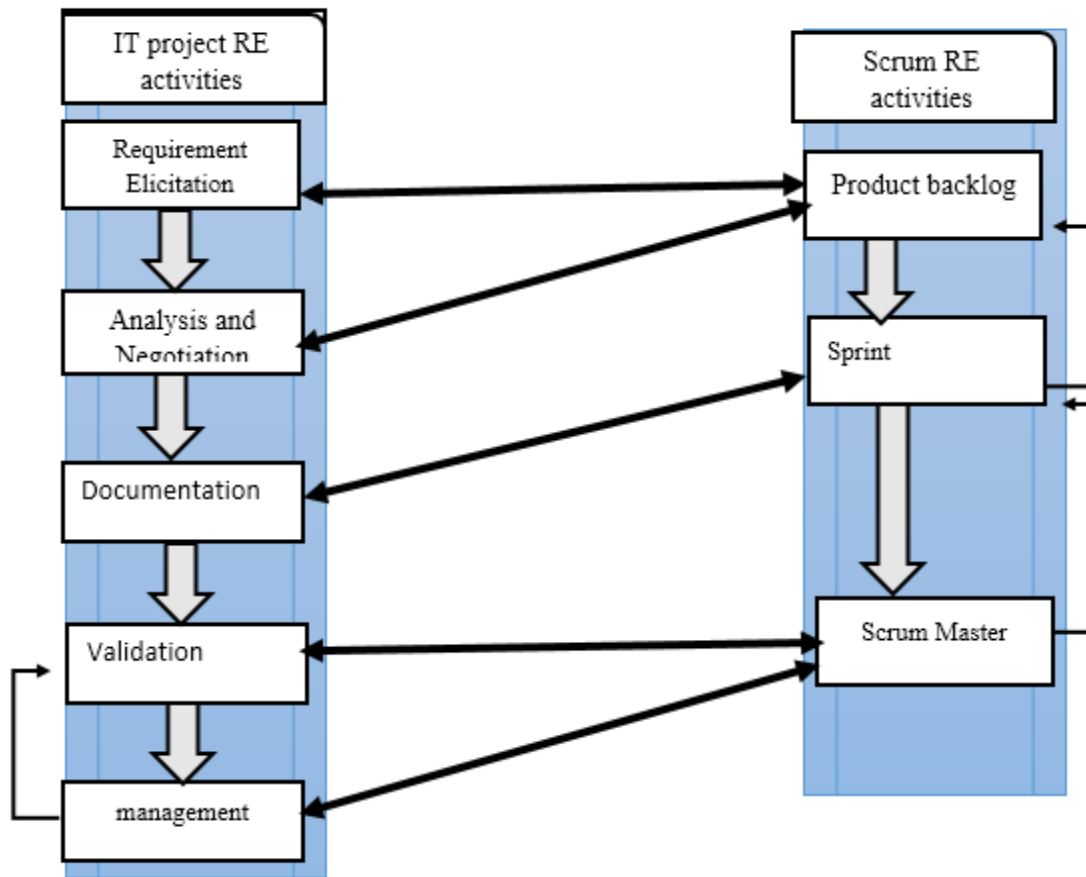


Figure 4.3: Integration model Requirement Engineering Process

Chapter Five: Result Analysis and Evaluation

5. Result Analysis and Evaluation

5.1. Result Analysis

Data collection from chapter three analyzed and based this result we have been deciding scrum agile approach is needed in E-healthcare projects. Based the analyzed data we down that the requirements engineering is the great impact on the developed project in E-healthcare of Ethiopia. Since the project is developing without the requirement engineering process in E-healthcare has the problem of high failure rate, misconception of the system requirements, late to delivery, involve the error on requirement elicitation, need the additional cost to fixed the error, and all stakeholders were not satisfied.

As the result, the requirements engineering has to focus on documenting the user (stakeholder needs) requirements as user stories. It helps to solve the problem of developed projects in E-healthcare. This implies that the requirement engineering process required the rigorous approach to an efficient requirement to develop healthcare IT projects with high quality. In this concept, the requirement engineering process in E-healthcare projects is used to determine the scope of the project, identify the impact requirement engineering and it analysis the proposed solution should look like.

The scrum agile approach is needed than traditional approach in E-healthcare projects to gather an efficient requirement resulted from respondents. Around 49.25% of respondent selected the agile scrum approach to gathering an efficient requirement of stakeholder needs. As figure 5.3 show us 76-80% has failure rate the project developed without requirement engineering in E-healthcare and stakeholder were no satisfied. Based on this result the requirement engineering process used to investigate the crucial model which help to develop the health IT project with high quality. Because of the requirement engineering process is a non-tangible process, the need of stakeholders is about 80% satisfy during the project developed being followed the requirement engineering process and rigorous approach.

In figure 4.2, the proposed model also shows us how to the requirement engineering activities are flowed on the developed project which is called DHIS project. This is enhancing to determine the scope of the project, business requirements, user requirement and system requirement the respondent respond on chapter three from the interview have suggested documenting.

Interview and questionnaires were response showed us that in current project the team is working on iterative and incremental flexible approach SDLC is being followed. On the previous E-healthcare projects were that the team have no requirement documentation. However, the proposed model is the rigorous model used to documented the requirement in the database as we show in figure 4.2.

RE process has direct relationship with the development of IT projects. If there is no RE process in the development IT project, the project has no scope, feasibility, plan release and quality of end products. Even if with traditional requirement engineering approach, the project has directly relationship with RE process. As result of figure 5.1 show that about 76.25 % strongly agree with the RE process has directly relationship with the development of healthcare IT project. The healthcare IT staff and plan and policy healthcare IT directorate strongly agree with this relationship. So, to fulfill the relationship we apply scrum approach and the rigorous RE model.

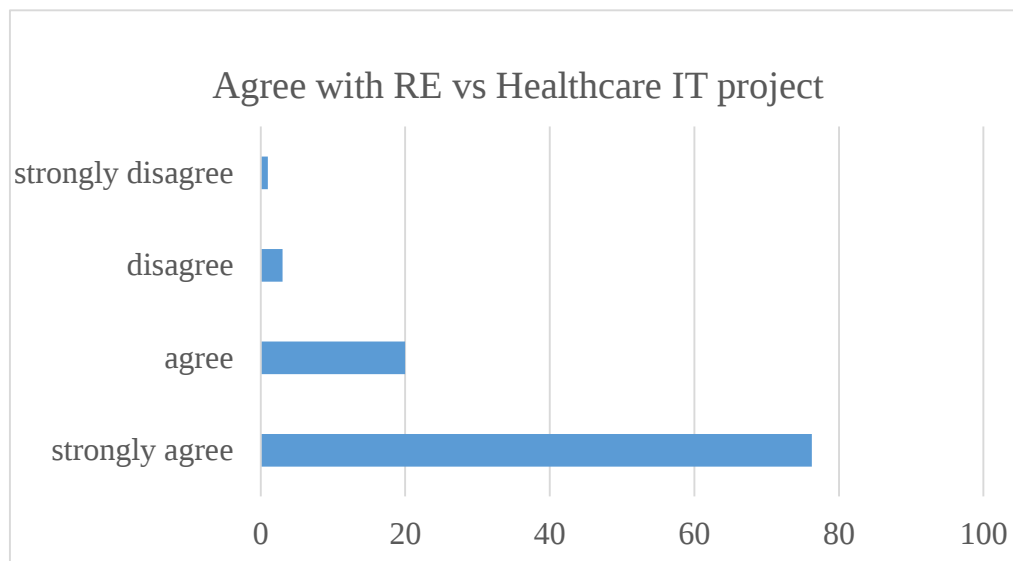


Figure 5.1: Relationship between RE and Healthcare IT project

The study has further indicated that in E-healthcare projects where many requirements engineering artifact is to be considered for the development of the solution, the quality of software is directly related to the requirement engineering effort on the project. The result from the response to interview about 76.25% respondent respond strongly agree or agree that requirement engineering directly impacts on the quality of end product. The majority of strongly agreeing ones were analysts. About 3 % disagreeing and not sure but the strongly disagreeing ones were no analysts. About 20.25% of the respondent was the response the change of requirements in developing the project is may be or agreed has a great impact on the analysis and design of it. The cost of software development increase and the project is late. As result, we develop a good model which prevent the problem of requirement change in E-healthcare.

Based on the project developed in E-healthcare of Ethiopia are late, cost estimation unknown, fail, and stakeholders were satisfying this is due to the requirement engineering process and rigorous model does not exist in the developing process. So now we the scrum agile approach to process the requirement engineering which help to solve the problem of gathering an efficient requirement and use to understand the stakeholder needs and increase the communication between the developer and the stakeholders. It used to improve the quality of service delivery in the sector and increase the satisfaction of stakeholders.

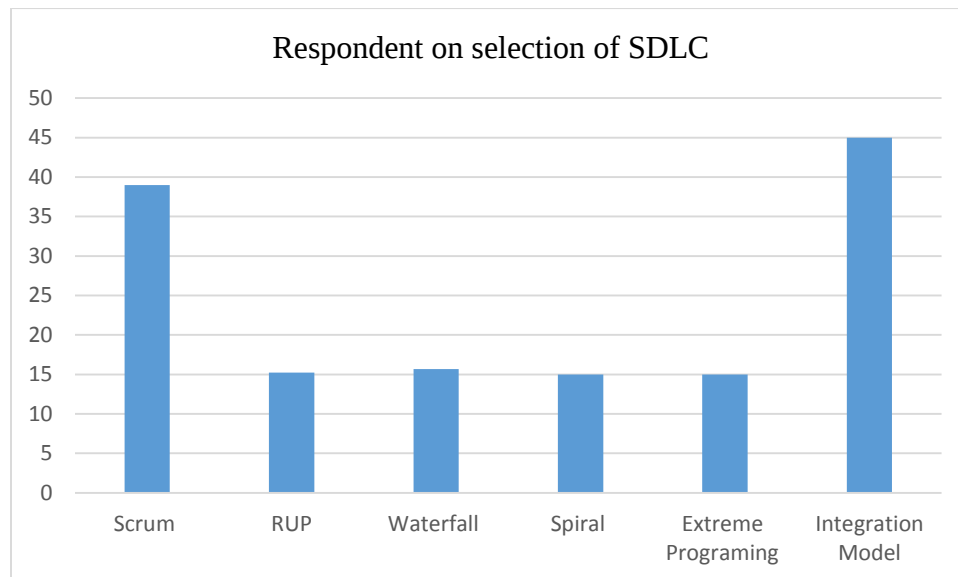


Figure 5.2 Impact of Integration model on SDLC

The proposed model is a flexible and incremental, iterative approach used to develop the software in high quality. It has great advantage than other SDLC approach because the scrum contains three things. These are the product backlog, sprint and scrum master. The healthcare IT project has meet of requirement with different phase of SDLC. So, the scrum also has its own phase of SDLC. The product backlog contains the prioritized requirement and send that requirement to the sprint for implementation. Thus, the sprint is group of team (people) then they implement the system based on received requirement. If any ambiguity on the requirement delivered from the product backlog, then the sprint send that requirement to the product backlog for requesting the change on the requirement. The health extension worker gather the requirement based on the REF that delivered from the PPHITD then the gathered requirement stored as product backlog. After the PPHITD has prepared the design of the system then the HITS implement the system through that requirement. The HITD manage overall process works as scrum master. As result, on figure 5.2 shows that about 49.25 % the scrum agile and the proposed model are suitable for development software in healthcare.

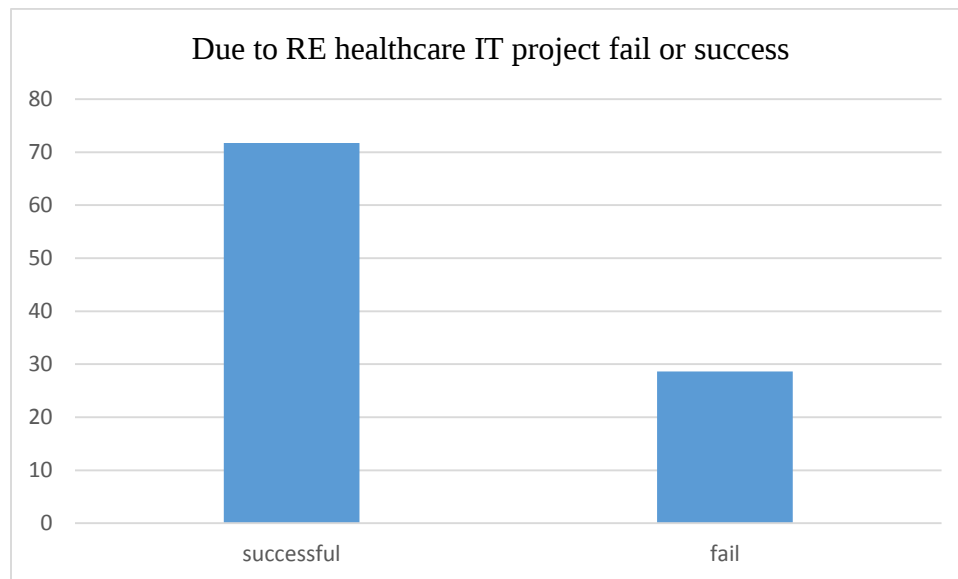


Figure 5.3: Respondents graph on success or fail

As figure 5.3 indicate that the stakeholder response in absence of RE process the project develop in healthcare is fail. RE has the impact on the software development of healthcare. The result shows that, about 72 % of the development healthcare IT project is success due to the RE process and the proposed model.

So, to overcome this failure of the development of healthcare IT project we proposed a scrum agile approach and we investigate RE process techniques through scrum. Thus a scrum agile approach has minimized the failure of healthcare IT project and increase the delivery of healthcare IT project

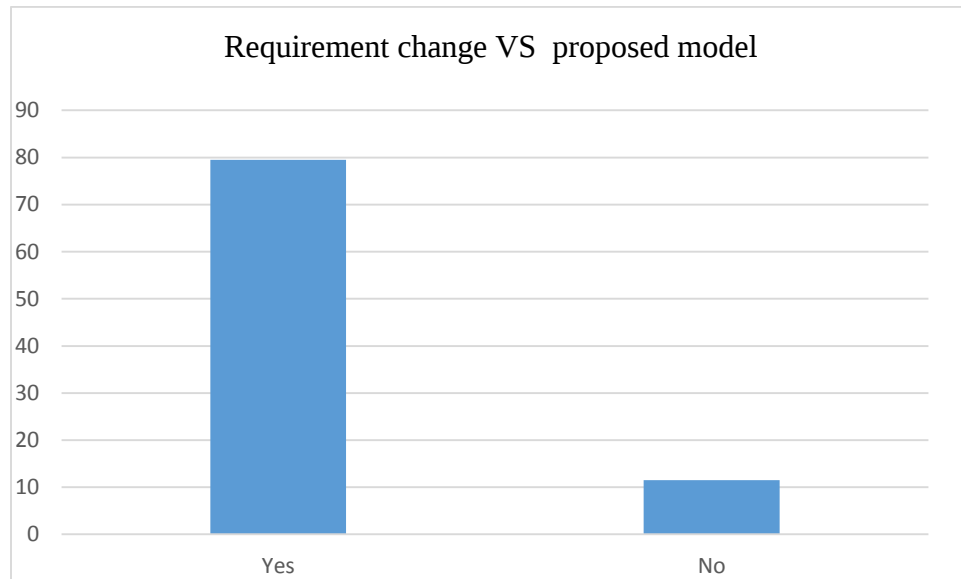


Figure 5.4: Change Requirement on Integration model

Requirement change has great impact on the agreement of software development life cycle. In behavior most of agile approach early know the expectation of stakeholder about the development of healthcare IT project. Thus, the scrum has important role in increase of the stakeholder satisfaction and better communication between the developer and stakeholders. In figure 5.4 result shows that about 79.5 % tolerate the change of requirement in development at any stage of SDLC.

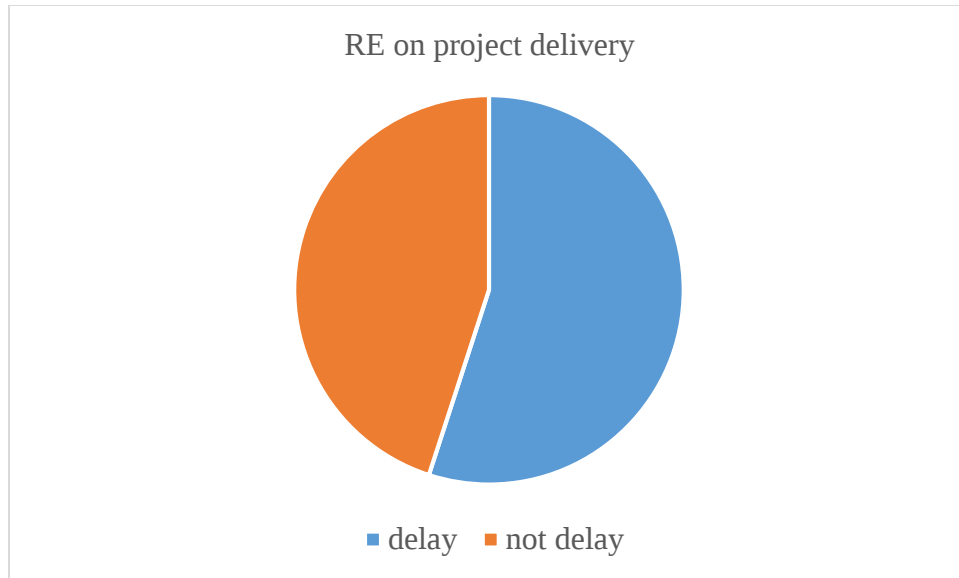


Figure 5.5 Respondent of Project Delivery

RE process has the impact on delivery of the development of healthcare IT project. Hence, software development is not late to delivery due RE process only but there are other factors such if there is no rigorous model that used to gather quality requirements to develop the software. As result show on the figure 5.2 around 55 % of healthcare IT project has the time of delay. So, to decrease the number of time delay of the development healthcare IT project were proposed the requirement engineering model and scrum approach.

5.2.Evaluation of the Model and Discuss the Evaluation Criteria

5.2.1.Evaluation of the model

To check the quality of collected requirements, many requirement quality metrics [56, 57] which are used to improve the quality of development of the project in the selected organization. It also prevents the failure of the project and avoid the ambiguity of requirements. To evaluate the proposed model of requirement engineering process in healthcare IT projects we decide the following the software metrics that adopted from the factors that affect the software development life cycle [58, 59].

- A. **Unambiguous:** since the requirement collected with any ambiguity and wrong precision of the requirements caused the failures development of the projects in healthcare organization. To measure the unambiguous of the requirement collected as follows

$$QUA = \sum \frac{R_{idr}}{N} \text{ to close one } \text{-----} \text{ (Eq4.1)}$$

Where R_{idr} is the number of identical requirement reviewed by reviewers.

N is the total number of the requirement that collected.

- B. Correctness:** define the functionality of the system but the requirement gathers through use case verbal language which lead vocabulary problem. So we validate the requirement using this formula:

$$QC = \sum \frac{N_v}{(N_{nv} + N)} \text{-----} \text{ (Eq4.2)}$$

Where N_v is the number of requirement validated.

N_{nv} is the number of the requirement still not validate

N is the number of total requirements

- C. Completeness:** This is exploring the quality of the requirement and due to uncertain the requirement is change so, to avoid the uncertainty of change in requirement and validate the completeness the requirement we apply the measure metric of completeness of requirements.

$$QCM = \sum \frac{R_i}{N_t} \text{-----} \text{ (Eq4.3)}$$

Where R_i is the number of identical requirement

N_t is the number of total requirements.

- D. Consistency:** To evaluate the validation of the requirements which suitable further use to develop the projects through the proposed model. To elaborate the consistency of the requirements we apply this measure technique.

$$QCN = \sum \frac{R_{ns} - R_s}{N} \text{-----} \text{ (Eq4.4)}$$

Where R_{ns} is the number of the requirements are not specifying

R_s is the number of the requirement specify

N is the number of total requirements.

- E. Availability:** define the requirement available at a given time of requirement analysis duration. We can calculate the availability of requirements by this metrics:

$$QA = \sum \frac{R_a}{(N_a * T)} \text{-----} \text{ (Eq4.5)}$$

Where R_a is the number of available requirement

T is a given time of available requirement exist

N_a is the number of total available requirements with a given time.

We can summarize the proposed metrics that in terms project without model and define model are as follows:

Table 5.2 Evaluation metrics of Model

<i>Requirement quality attributes</i>	<i>Project without model</i>	<i>Project with define model</i>	<i>Purpose of the measure</i>	<i>Result</i>	<i>Result Analysis</i>
Unambiguous	Not define	define	To measure the value of negotiation requirements and to increase the quality of requirements	0.8976	When it is closed to one, it is unambiguous requirements
Correctness	Not define	define	To illustrate the validation of the requirement	1.0045	Almost it is correct
Consistency	Not define	define	To evaluate the continuity of requirement and used to specify the functionality of the system requirement	0.8956	The model is consistency according the result
Completeness	Not define	define	To check the changeable of the requirement	1.0056	It exact one so it is complete
Availability	Not define	define	To define the amount of time that use the requirements	0.7896.	It is closed to one

When we elicitation the requirements for specific project development life cycle we consider the quality of that requirements. To increase the quality of the requirement, we must apply the requirements quality attribute as shown table 5.2. Almost all of the requirements quality attributes are defined using project develop with define model. In our proposed the rigorous model for gather the requirement with high quality for development of healthcare IT project of Ethiopia we define additional metrics for evaluate the model. The mathematical representation those metrics were drive from collected requirements. This is the simple way of define the requirement quality attribute in software development life cycle. Emphasis that if and only if one project developed

successfully without any defects in healthcare IT project when it is applying the rigorous model and requirements engineering process. So, the proposed model has great impact on the development projects in the healthcare and it is evaluated by software metrics as shown in the table 5.2.

One model is an efficient model used to develop the software with high quality when it is applied the requirements quality attributes. The proposed model is better than other in the healthcare organization. It increases the quality of gathering an efficient requirement, by this scenario we have the advantage of increase satisfaction of stakeholders need, improve the quality of the project and the quality of the service delivery in the sectors. We also evaluate the proposed model through the following parameters and metrics which indicate the amount of degree over the parameters: these metrics are high with a value of 12, medium with a value of 2 and low with a value of 1. The model evaluates by the respondent around 82% response the proposed model solves the problem of user involvement in developing process, the satisfaction of stakeholders needs and increase the communication between the developer and the team of the projects. It also increases the transparency of the project cost estimation, avoid the error in requirement elicitation and time-consuming. As we observe the table 5.2 in below the project developed through the proposed model has a high quality of software development life cycle. We try to put this model as the best solution for improving the quality of healthcare IT project in the Ethiopia.

Table 5.2: Evaluated metrics of Respondents.

<i>Proposed parameters</i>	<i>Existing system</i>	<i>Project developed without model</i>	<i>Project developed with proposed model</i>	<i>Respondent response in (100%)</i>	<i>Number of respondents</i>
Use involvement	-	low	high	High =12 Medium= 0 Low =1	32
Stakeholder satisfaction	Low(2)	medium	High (2)	High =24 Medium= 2 Low =2	32
Better communication	Low(2)	medium	high	High =12 Medium= 2 Low =2	20
Time consuming	high	Medium	low	High =12 Medium= 2 Low =1	32
transparency	-	medium	High (2)	High =24 Medium= 2 Low =0	20
Total Result of high value $\sum_{HV}$				84	

Chapter Six: Development of the Prototype

6. Development of the Prototype

In this chapter, we illustrate an overview of the prototype implementation of the investigated requirement engineering model in healthcare suitable for the development of software that elaborates in chapter four. At the end of this prototype, we mainly focusing on the implementation of some part of the web based requirements gathering system. This is the way of gathering quality requirements and better communication between the developers, the team, and the stakeholders. The accessibility of this web-based interfaces from any browser using URL of the system, the functionality of the linkage n between each menu. The prototype access through portability or tablet device interface and desktop or laptop layout of the developed prototype and other important features for improving the concept. To implement the prototype of the model and to describe the implementation in details we used different model software description approach.

In this subsection of the chapter, we have described model description approach pointed out the system use case. Then we have described the web based requirement gathering system for developing a prototype using software modeling view software modeling view [6]. At the end of this chapter, we have an explanation of the advantage of web based requirement gathering, the implementation in details, the result analysis, and discussion to develop the quality IT projects in healthcare of Ethiopia. The modeling view that used to implement the prototype are a logical view, process view and use case. We describe briefly these view as follows.

Logical View: This view shows how the functionality of the system provides to users as service. The presentation of this view is a sequence diagram, class diagram, and collaboration diagrams.

Process View: To apply non-functional requirements in the system using this view which can represent by the UML activity diagrams.

Use Case: presented by UML use case diagrams and show the interaction between the features of the system and their actors. When we chose the specific parts of web based requirement gathering system to evaluate the proposed model for improving the healthcare IT projects.

6.1. Use Case

The most proper selective use case for implement the prototype of web based requirement gathering system are shown in Figure 6.2. The figure incorporates most important use case of the prototype. We describe each use case as follows.

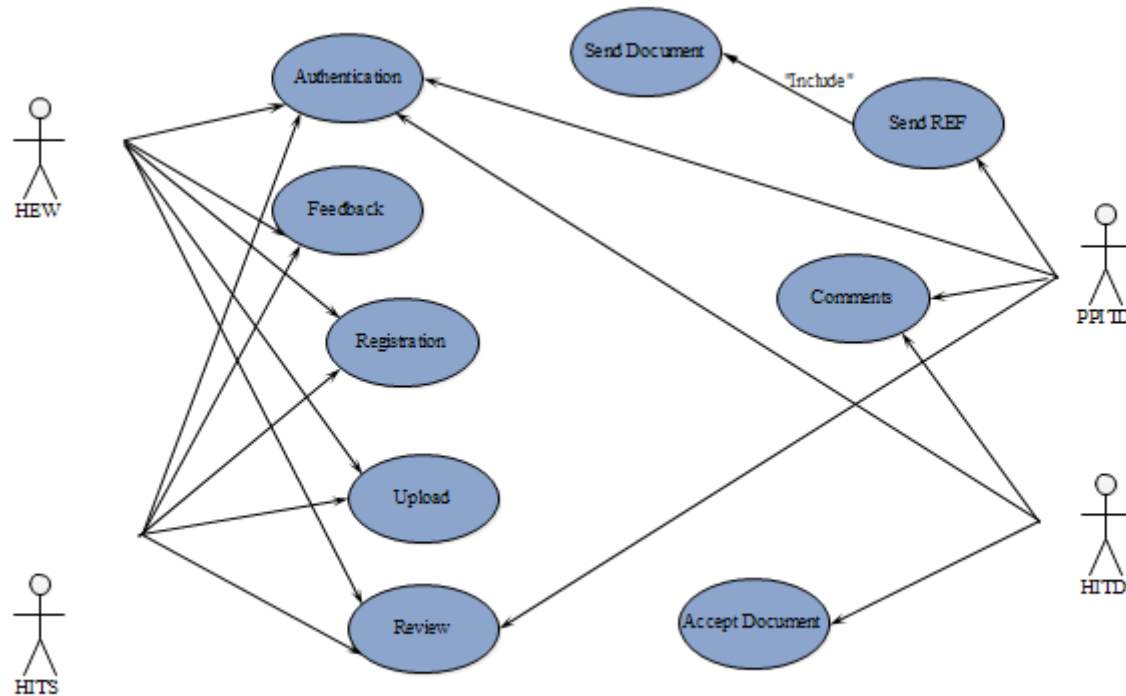


Figure 6.2: Use Case

6.1.1. Authentication

Use Case Description: a use case description will generally include:

1. General comments and notes describing the use case of the system and it is describing the system's actions from the point of view of a user.
2. Requirements: things that the use case must allow to user to do, such as <ability to login>, <ability to review> and etc.

Pre-condition Description: <registered> must precede.

Post-condition Description : < gives feedback>, <review>

3. Scenario sequential description of the steps that taken in the following use cases.

6.1.2. The Description of Health Extension Worker

The health extension workers after they registered they are authenticated on the system.

Pre-condition Description: <ability to browser URL>, <ability gives the feedback>.

Post-condition Description: <ability review the requirement exchange format>, <save the requirements>.

6.1.3. The Description of Plan and Police Healthcare IT Directorate

Pre-condition Description: <review feedbacks>, <ability to send REF>, <ability to send documents>.

Post-condition Description: <review>, <ability to giving comments>

6.1.4. The Description of Healthcare IT Directorate

Pre-condition Description: <review the document>, <manage>, <give the comments>.

Post-condition Description: <provide to accept the document>.

6.2. Logical View

The logical view of the web based requirement gathering system (WBRGS) is illustrated by using a sequence diagram, the diagram shows that the ability to gathering the requirements and controlling the other feature of the WBRGS.

The figure 6.3. show us how to gather the requirements from health extension worker and analysis the concerning bodies like analysis and design the collected requirements, specified the system requirements by the HITS and validate and manage the change of requirement then store the requirement in the preferable database to further used.

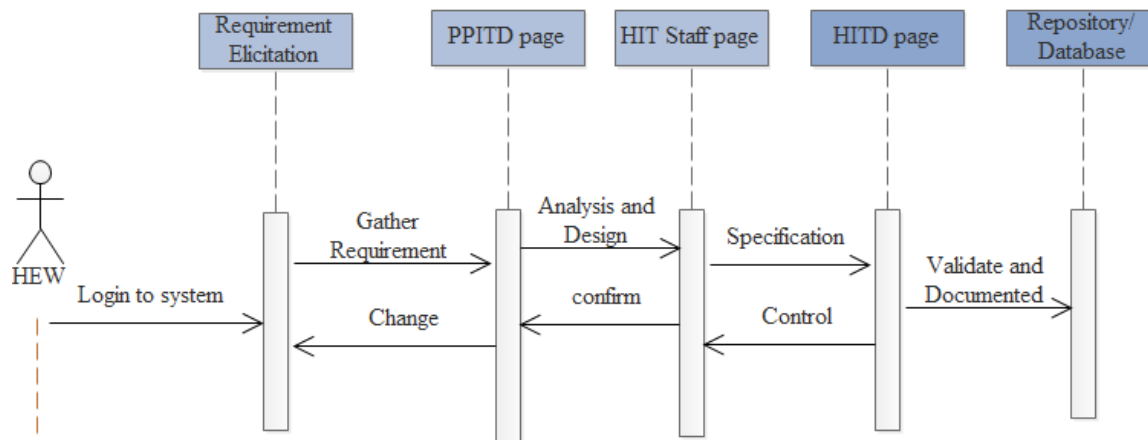


Figure: 6.3. Sequence Diagram-Web based Requirement Gather System

Steps to gathering the requirements of sequence diagram for DHIS project

1. Plan and police healthcare IT directorate prepare the well to define requirement exchange format (REF).
2. The REF is evaluated by the ministry of health IT directorate.
3. Write the project proposal and find out sponsor.
4. Present the proposal to the ministry of healthcare of country.
5. Again, the ministry of health IT directorate has been evaluating the proposal.
6. After the proposals are accepted, the plan and police healthcare IT directorate the prepared REF for second time
7. Send REF to health extension worker (HEW) with some description of the system.
8. The plan and police healthcare IT directorate (PPITD) get feedback by REF from HEW
9. Requirements were analysis and designed by PPITD that comes from HEW.
10. Send analyzed and designed requirements to healthcare IT staff (HITS).
11. Based on the designed requirement the healthcare IT staff implement and specify the system.
12. The HITS send the specify requirements to PPITD as feedback.
13. The PPITD validate the requirements with gathered from HEW
14. The PPITD checks the feedback as a checklist.
15. The PPITD See the change of requirements that come from both feedbacks.
16. The change of requirement from HITS used to check designed for the requirements.
17. The PPITD send the REF to HEW to get clarity of the elicitation requirements.

18. The HEW reviewed the REF to additional information.
19. The HEW send the REF to PPITD with update information.
20. The PPITD analyzed and update the designed based on the update REF feedbacks from HEW.
21. The PPITD sent updated design to the HITS as a document format.
22. The HITS review the document to get update information.
23. The HITS implement the system based designed requirements that demonstrate on the document reviewed from PPITD.
24. Repeat step 12 to 22.
25. Validate and documented by HITD.
26. Store the requirements elicitation from HEW in the database as user stories and release the projects or system functionality.

The PPHITD prepared the REF then validate by HITD as shows on the sequence diagram 6.3. REF is the requirement gather format which has the description about the development healthcare IT project.

6.3.Process View

The process view of the WBRGS is exploring by using activity diagrams that corresponding the registration, logging and gathering the requirement on the system. Figure 6.4 shows the registration and login process to be part of the WBRGS the HEW/PPHITD have access privilege to the system. The activity login by requesting the registration and login through the registration form and login features of the system. The registration form is available to the user and if the user is correctly fulfilling the available form, then the users were registered to the system. However, if not the error message is displayed for them and they fulfill the registration form again until they fulfill the form correctly and the process will be finished.

Overall of the WBRGS activity diagram that describes by the figure 6.5 the HEW gathering the requirement through the system for healthcare IT projects. Thus, used to develop the project with an efficient requirement imply that to increase the quality of developed projects. If gathered requirements were not feasible then the HEW have elicited the requirement again until it is feasible through the requirement exchange format (REF). But the gathered requirements were feasible to the plan and police healthcare IT directorate then the HEW review the acceptable confirmation from PPHITD. After all of the processes fulfilled the process of activity will be the end. One

another if analyzed and designed requirement is not clear, then the HITS are sent feedback to PPHITD to understand the designer of that requirement.

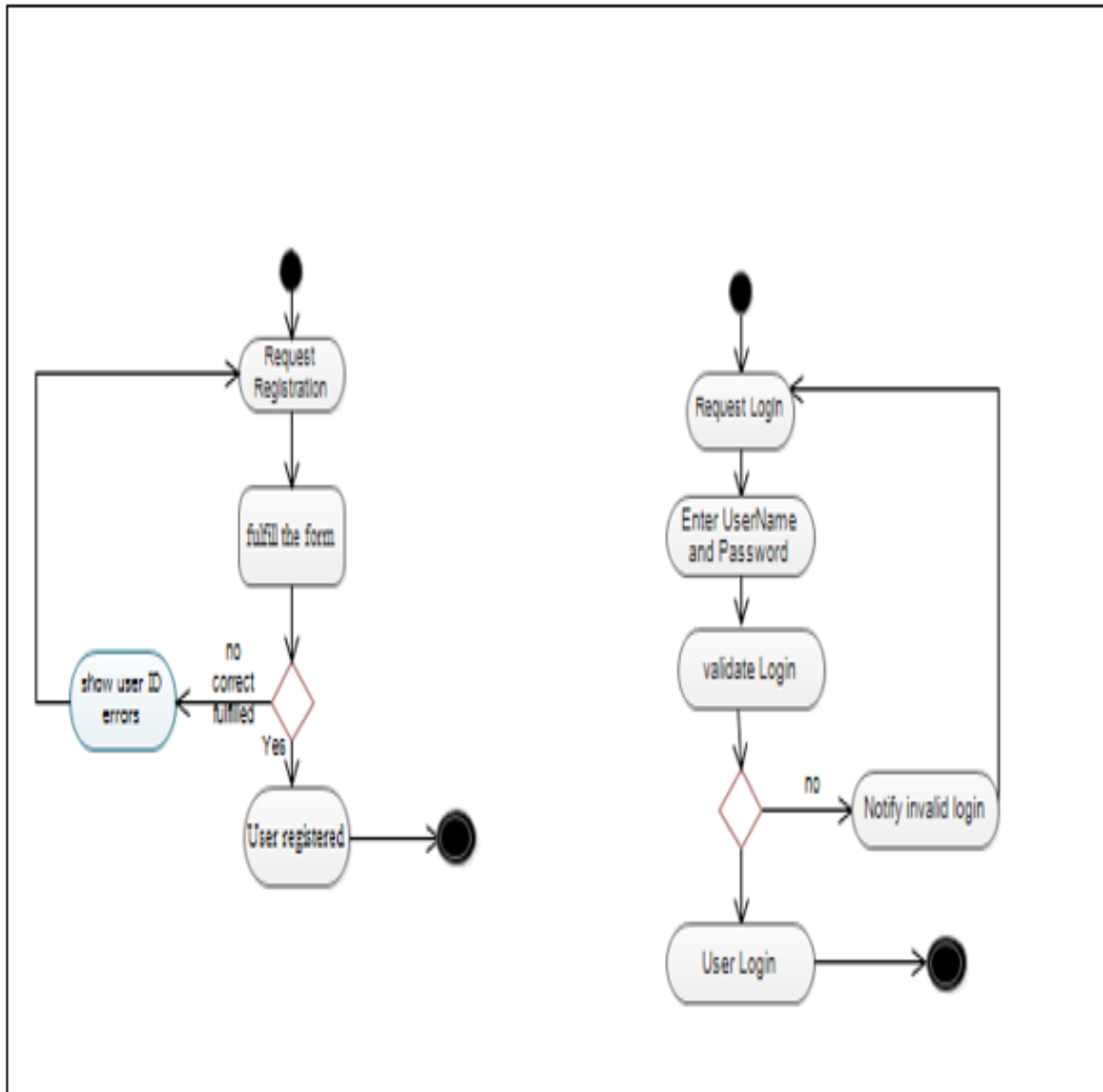


Figure 6.4: Activity diagram for Registration and Login

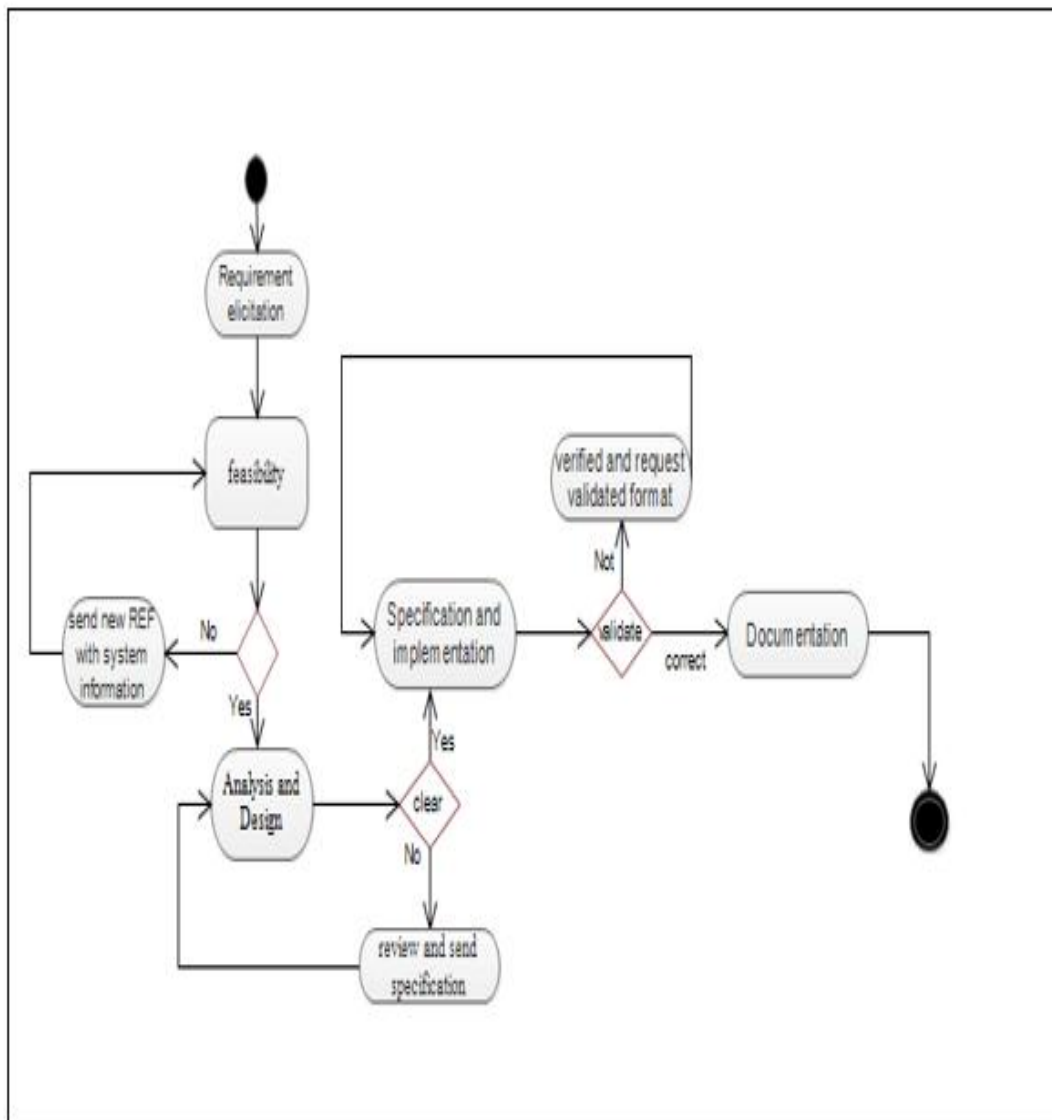


Figure 6.5: Activity diagram for requirement elicitation for DHIS

6.4. Class Model

The data model is the primary supports for the functional requirements and it defines the services that system should be provided to the users. The data model also used for avoiding the complexity of the WBRGS is shown in the figure 6.6 we are not providing details of the system entity. We illustrate some entity of the system by showing the relationships that inform of the aggregation and composition of services corresponding to the entity whereas the relationship between entities in maintains at service level i.e. the relation between entities inside entity is maintained at database level i.e. in forms of referential integrity constraints. The WBRGS has from one to several users and mostly the WBRGS has stored the stakeholders needs as user stories in the database/repository.

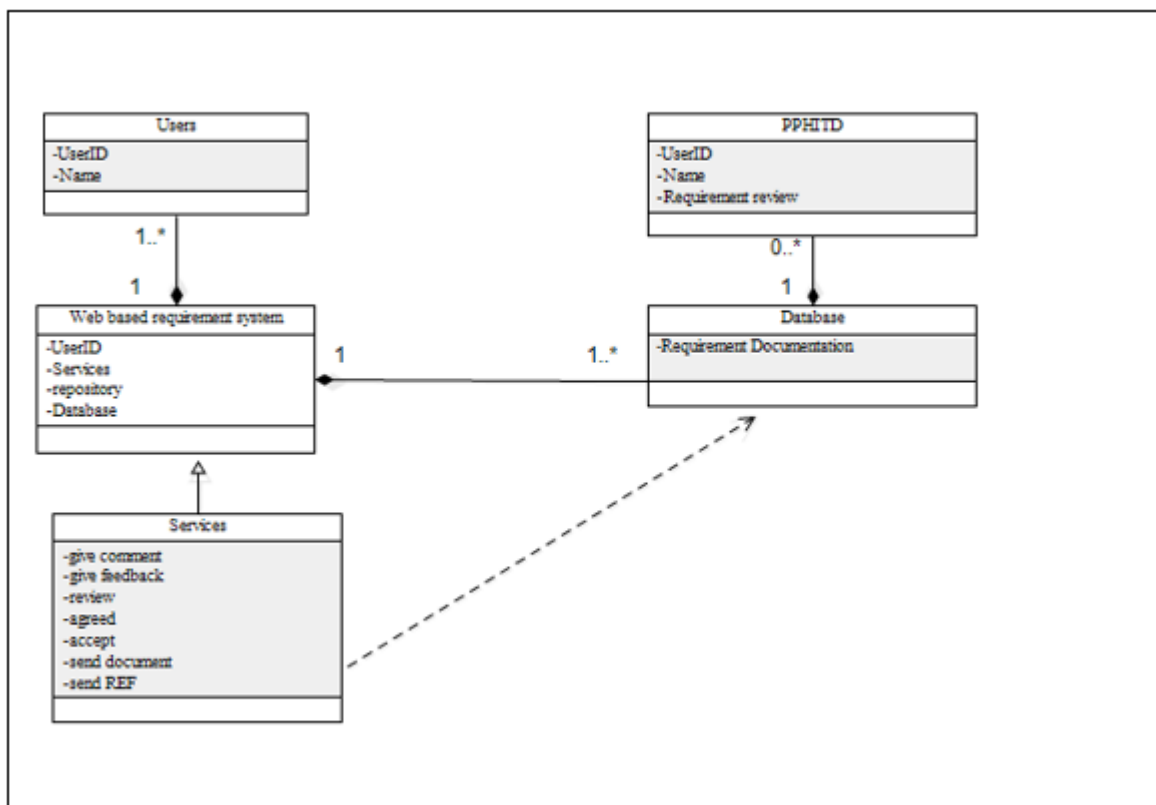


Figure 6.6 Class Data Model

6.5.Implementation of the Prototype

The WBRGS is the way of simplifying the burden of requirement gathering for developing the healthcare IT projects. The tools or technologies that used to develop the prototype of WBRGS are:

- Asp.Net, CSS, and HTML for designing an interface of the web application.
- Visual studio language for tackled the prototype
- .Net framework platform used for creating and testing
- SQL server used to store the data as a repository.

The prototype is designed for desktop and laptop device. In figure 6.7 shows the visual studio web console. This is implying that how we develop the web application using visual studio with integrate framework. The screenshot or the web interface show the health extension worker page and the window how the health extension worker gathers the requirement using the web application shown in figure 6.7.

Welcome to Webbased Requirement Gathering Site

Region	
Zone	
Woreda	
Name	
ID	
Mobile no	
Date	
Requirement	Browse... Respondent name.docx
	UpLoad

Figure 6.7 Web-based Requirement Gathering System Development Process.

In figure 6.7 shows that the interface of how the health extension worker gathers the requirement using the develop prototype and they fill all the requirement send to the plan and policy healthcare IT directorate then the requirements analyzed and designed the system model to implement the healthcare IT project with understood the needs of all stakeholders.

6.6. Analysis and Discuss the Implementation

Web-based system gathering requirement is the way of increasing the efficiency of the requirements. The process of requirement engineering through the development web which increases the quality of requirement gathering in E-healthcare system that we developed. We develop the model which help for such matter and the model also used to gather the requirement using this web from the district of the country by means health extension worker. The system has solved the problem of the requirement elicitation and burden factors that to develop any IT projects in Ethiopian healthcare. So, the best solution for improving the quality of requirements elicitation in software development life cycle in healthcare. Indeed, if we increased the quality of requirement elicitation we also increase the quality of end product and increase the satisfaction of stakeholders.

Additional this system not only for the requirement elicitation matter but also, it's used to solve the problem of wasting resource, time and reduce the human labor. In the case of Ethiopia, as we reviewed at literature review and related work and interview the ministry of healthcare of Ethiopia information technology department staff, almost all the healthcare system develops through partner and customize from another country and adapted it. So, based on this factors we develop requirement engineering model which help to improve the quality of the system developed in healthcare. The healthcare system developed using this model is DHIS, which increase attempt to achieve the goal and vision of the organization.

6.7. Evaluation of the prototype

Evaluation is the process of checked whether the system was correctly worked and validate the component, justify whether the stakeholders were satisfied or not with the developed system.

6.7.1. User Acceptance Evaluating

WBRGS should be deployed for healthcare requirement gathering, the users that tested were the PPHITD, HITS, HEW, HITD and other healthcare professional the developers and researcher working in the ministry of healthcare. User acceptance testing was done by perspective the above

users. It also was performed on how to use almost all users of the WBRGS and the easiness of the interface to use. They suggest the related issue and give some comments on the prototype. As we have shown in table 6.3 how the PPHITD and knowledge seekers interact with WBRGS and rate of their feeling about this web application.

Table 6.3: User Acceptance Evaluation

No	<i>Ability to do</i>	<i>Metrics of testing</i>	<i>Technical issue</i>	<i>No of tester</i>
1	Sending REF over the WBRGS	Correctness is very high	Easy to use	5
2	Give feedback and review	Better	Highly automobile	5
3	Requirement Change management	Complete	Very easy	5
4	Send document	High consistency	Good	15

Technically this prototype designed was checked by the PPHITD, HEW, HITS, colleague and expert from software engineering and related fields and they provide their comments and suggested about the prototype which very useful for the healthcare IT projects development in the country. They recommend that the prototype should be more user-friendly and easy to use the performance in more effective manner. It is very important for healthcare and ministry of agriculture for developed any system in an efficient manner if full implementation of the prototype is performed.

Chapter Seven: Conclusion and Future Work

7. Conclusion and Recommendation

In order to investigate the requirement engineering process in a healthcare organization, we apply requirements engineering approach. Requirements engineering is the crucial things to develop any project in the software industry. Healthcare is one the most industry which IT projects are developed because at all-time information is being processed. Due to the requirements engineering the development project in healthcare is fail or not successfully implemented and most of the stakeholders were not satisfied. To demonstrate the requirements engineering process we must have the rigorous approach. Now today most software works with the adoption agile approach to developing an IT project because of the stakeholder needs are change through all time, different business idea and rapid growth of technology. Healthcare is one of use adaption agile approach that determines the needs of requirements engineering and the rigorous approach to developing the project within an efficient requirements engineering.

In Ethiopia, the healthcare IT projects are developed without requirements engineering process and rigorous approach before the model was proposed. Due to this factors, the project developed in healthcare were failed, not satisfy the stakeholder, decrease the quality of gather requirements and increase the delay of project delivery to functionality. With an inefficient requirement engineering and unpredicted approach in the previous year healthcare, IT projects in Ethiopia. Thus, it indicates the healthcare IT projects had the problem of stakeholder involvement in developing projects, no user satisfaction on the developed projects, most of the projects were failed, and due to this constraint, the healthcare IT projects asked additional budget to fix the error. But Ethiopia is the developing country so, she hasn't additional budget for such problem. Generally, to address this gap we proposed a scrum agile approach and we must give great attention to requirement engineering in developing healthcare IT projects.

The scrum is the most popular flexible an incremental and an iterative approach which increases the stakeholder involvement in developing process. With this scenario, the satisfaction of stakeholders is increasing and there is better communication between the stakeholder and the developer teams which increase the understanding the needs of the stakeholder and develop an efficient healthcare IT project. So, as result, we proposed this model to solve the complexity of project failure, user satisfaction and involvement, and the management of requirement change at any phase of software development life cycle.

Finally, we conclude this thesis by recommending the ministry of healthcare of Ethiopia use this proposed model to increase the quality of end product, improve the quality of service delivery in the organization and used to achieve the goal and vision of the ministry of healthcare of Ethiopia.

7.1. Future Work

In future direction study on the requirement engineering process in Ethiopia is if we study how the use of the central repository that used to store an investigated requirement. Then the central repository overcomes the problem of ambiguity, vague, translation problem, semantic, and reduce the cost and time of requirement elicitation.

Additional further study of thesis how to apply hybrid approach on requirement engineering process that used to develop a new E-healthcare in the country for a different organization. The integrated approach has more advantage than a single approach. Both approaches have their own advantage and disadvantage implies that traditional requirement engineering approach has its own advantage and disadvantage and the agile requirement engineering approach also its advantage and disadvantage. Thus, needs a study of integrate approach in the country and how change gathered requirements translate into meaningful system requirements. Identify system requirement is another challenge in Ethiopia, healthcare IT Projects.

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Appendices

Appendix1: Interview Questions and questionnaires:

Instruction: choose the best following indicators that you want emphasis.

1. Due to absence of requirement engineering process the healthcare IT projects are

 - A. Strongly successful
 - B. Very successful
 - C. May successful
 - D. Failure
2. Are you satisfying within the existing E-healthcare system in the absence of requirement engineering process?
 - A. Strongly satisfy
 - B. Satisfy
 - C. May satisfy
 - D. Not satisfy
3. Do you agree with the quality of the healthcare system is directly related to requirement engineering process?
 - A. Strongly agree
 - B. Disagree
 - C. Strongly disagree
 - D. Not sure
4. Which approach is better used to development of software in E-healthcare you choose?
 - A. Scrum
 - B. Extreme programming
 - C. RUP (Rational Unified Process)
 - D. Spiral
 - E. Waterfall

5. Is project in E-healthcare delivery late due to requirement engineering?
- A. Yes
 - B. No
6. Does change of requirement an impact on development cost in E-healthcare project?
- A. Agreed
 - B. Maybe
 - C. May not be
 - D. No
 - E. Not sure
7. The project is developed in E-healthcare without has better communication between the developer and the team of the project?
- A. Yes
 - B. No
- If there justify it -----

8. How much to time consuming the project development without the requirement engineering?
- A. High
 - B. Medium
 - C. Low
 - D. Nothing
9. Is there the transparency of budget through the development of the project without the rigorous requirement engineering approach?
- A. Yes
 - B. No
- If there define it in words -----

10. How many percentages of user participate in developing the project in healthcare with rigorous requirement engineering approach?
- A. 70-80%
 - B. 10%

C. 5-15%

D. Less

Appendix 2: Interview questions

Can you describe how a typical workday looks for you?

What type of approach did you use to develop a software in healthcare?

Have you experienced doing on the requirement engineering process in developing process?

Have you seen the impact of requirement engineering on the development of any healthcare IT projects?

How is scrum agile approach best to gathering an efficient requirement to you?

Are you satisfying with existing systems?

How does this affect your work role in the use of Scrum, why are you using system development methods in your work?

How did you use the methods and techniques in the past, do you have any noticeable change of any effect?

Appendix 3: Sample code

GUI code

```
<html xmlns="http://www.w3.org/1999/xhtml">
<head runat="server">
  <title> health extension work</title>
</head>
<body>
  <form id="form1" runat="server">
    <div>
      Gridview of interface
      <asp: SqlDataSource ID="SqlDataSource1" runat="server"
        ConnectionString=" <%%$ ConnectionStrings: LoginConnectionString %>"
        SelectCommand="SELECT * FROM [hew]"></asp: SqlDataSource>
      <asp: GridView ID="GridView1" runat="server" AllowPaging="True"
        AllowSorting="True" AutoGenerateColumns="False" DataKeyNames="ID"
        DataSourceID="SqlDataSource1" EnableModelValidation="True" Width="507px">
        <Columns>
          <asp: CommandField ShowEditButton="True" />
        </Columns>
      </asp: GridView>
    </div>
  </form>
</body>
</html>
```

```

        <asp: CommandField CancelText="" ShowDeleteButton="True" />
        <asp: CommandField ShowSelectButton="True" />
        <asp: BoundField DataField="Region" HeaderText="Region"
            SortExpression="Region" />
        <asp: BoundField DataField="Zone" HeaderText="Zone" SortExpression="Zone" />
        <asp: BoundField DataField="Woreda" HeaderText="Woreda"
            SortExpression="Woreda" />
        <asp: BoundField DataField="Name" HeaderText="Name" SortExpression="Name" />
        <asp: BoundField DataField="ID" HeaderText="ID" ReadOnly="True"
            SortExpression="ID" />
        <asp: BoundField DataField="mno" HeaderText="mno" SortExpression="mno" />
    </Columns>
</asp: GridView>

</div>
</form>
</body>
</html>

```

Appendix 3.2: Connection database code

```

public partial class empform: System.Web.UI. Page
{
    SqlConnection con = new SqlConnection (@"Data Source=dagne-PC; Initial Catalog=db1;
Integrated Security=True; Pooling=False");
    protected void Page_Load (object sender, EventArgs e)
    {
        if (! IsPostBack)
        {
            display ();
        }
    }
}

Connect table name with field

protected void btnadd_Click(object sender, EventArgs e)
{
    con. Open ();
    string str = "insert into temp1 values(" + Txtregion.Text + "," + txtzone.Text +
        "," + txtworeda.Text + "," + txtname.Text + "," + txtmno.Text +
        "," + txtid.Text + "," + txtfeed.Text + "," + Date.Text + ")";
    SqlCommand cmd = new SqlCommand(str, con );
    cmd. ExecuteNonQuery();
    lbmsg. Text = "record is successfully saved";
    con. Close();
    display ();
    cleartxt ();
}

```