University of Benghazi
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Design a Prototype Model for Mobile Disease Diagnosis Based on Decision Support System

A thesis submitted to the Faculty of Information Technology in partial fulfillment of the requirements of Master's degree in Computer Science

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Dedication

To the persons who deserve, more than that can be written with words.

My parents

Acknowledgements

I dedicate this humble work to Allah, The Merciful.

I would like to express my sincere thanks to my supervisor ***Dr. Mohamed Khlaif*** for his guidance and valuable remarks. This work is never been published without him. I am deeply indebted to ***Dr. Mohamed Hajal*** who generously helped me.

Special thanks to my ***family*** and my husband ***Moustfa*** for his assistance.

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Abstract

In recent years, the Decision Support Systems (DSS) have gained an important role in the research of information systems, where the DSS expiration are used for systems and applications that aim at helping work teams or users to make decisions. This is achieved by providing them with suitable and useful information to solve problems. As we all know that the success of any institution depends on the quality of decisions made. Such good decisions are genuinely made through data analysis and most importantly, specific knowledge is required by those who run any institution or organization. These two essential elements help a lot in the decision making process.

Generally speaking, we are fully aware of the importance of the increasing popularity of mobile technology and the vital role it plays in so many fields and specialties in the modern world. As we know mobile technology is basically applied in many domains including scientific, technical and business applications. It is very clear that this widespread technology is becoming more and more integral part of our everyday lives, many reasons are behind making this technology so popular and universal among millions of users around the world, accessibility and speed are two well-known features for mobile technology nowadays.

The goal of this research work is to use the Decision Support System with mobile technology characteristic in medical field. This DSS application provides medical diagnosis and advice for patients in order to take a certain decisions for any further possible medical treatment. All of this is based on the proposed solution approach, which is influenced with Decision Support Engineering methodology (DSE).

Keywords: Decision Support System (DSS), Mobile Technology, Decision Support Engineering (DSE).

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List of Abbreviations

DSS	Decision Support System
DSE	Decision Support Engineering
CDSS	Clinical Decision Support Systems
CBR	Case Based Reasoning
KB	knowledge Base
KBS	knowledge Based System
UI	User Interface
CBIS	Computer Based Information Systems
ES	Expert Systems
EIS	Executive Information Systems
AI	Artificial Intelligence
GPS	Global Positioning System
SMS	Short Message Service
MMS	Multimedia Messaging Service
GPRS	General Packet Radio Service
WLANs	Wireless Local Area Networks
CDPD	Cellular Digital Packet Data
PCS	Personal Communications Systems
GSM	Global System for Mobile Communications
VPN	Virtual Private Network
IVRS	Interactive Voice Response System

CHAPTER 1

Introduction

1.1 Introduction

Over the past decades, Decision Support Systems (DSS) have gained a major interest among academics and practitioners. They have become essential in the field of information systems as some types are used for example in managerial decision making. The general meaning of the word decision is the ability to take the best choice based on a set of suggesting alternatives. According to [1] [2] [19] Decision Support System (DSS) “is an interactive computer-based system or subsystem intends to help decision makers use communications technologies, data, documents, knowledge and models to identify and solve problems".

Decision Support Systems are gaining increasing popularity in various domains, including business, engineering, military, and in medical fields in order to do diagnoses for patients and determine appropriate treatment [39].

In addition there is no question about the importance of mobile technology and its influential role in our daily life. According to [9][14] the term Mobile Computing is “a generic term that refers to technologies that allow you to take your computer with you, and use it to describe the usage of computing devices, which interact in some way with a central information system that is away from the fixed workplace”. The most important advantage of this technology is that it allows the users to communicate with anyone whenever and however, and can interact with the service providers through a mobile and wireless network, using mobile devices for information retrieval and transaction processing [11], and these service like messaging (SMS, MMS, GPRS), email, packet switching, WAP and Bluetooth.

It's important to mention that the increasing power of mobile computing and widespread of mobile devices has made a remarkable success in the area of decision making process. Now accurate and more confident decisions can be made by using a mobile decision aid where traditional decision support systems did not allow this among decision makers.

There are many examples which can illustrate the use of mobile information technology in decision support systems such as helping consumer mobile- DSS in retail store to choose a best product from set of options [3] [4] [33], solve problems in a dynamic group decision making by using a special model based on mobile-DSS [5], developed a smart mobile systems to support organizational decision-making to create a highly dynamic form of decision support systems called network-DSS (NWDSS) [31].

The variety mobile technology provides for DSS has very much caught our attention and inspired us. Based on the possible methods and techniques that are used in decision support systems, we do believe it is feasible to implement such methods and concepts of mobile technology in the medical field especially in diseases diagnosis.

In this thesis, we present a prototype model for the diseases diagnosis that basically helps patients to know about their health check at a specific time. Based on the diagnosis given, the prototype model also provides a patient with quick medical advice especially when access to healthcare needed is not available or hospitals are too far.

The proposed prototype basically attempts to make the diagnosis procedure easy and reliable. It simply takes health information from patients through using the mobile device and then compares this processed information with the cases in a knowledge base. Finally it displays the results (output) on the mobile device.

The main aim of this thesis is to propose and use suitable DSS methods starting with analyze and design the system phases. This mechanism or method is known as Decision Support Engineering (DSE). We use this methodology to describe the functions of the system (see Section 3.3 in Chapter 3) and then determine the type of DSS we will use.

Where DSS have more than one type (See Section 2.2.6 in Chapter 2). The type we will use in our work is knowledge-driven DSS. It specifically “can suggest or recommend actions to managers and consists of knowledge about a particular domain, understanding of problems within that domain, and skill at solving some of these problems” [40]. This knowledge is represented in Case Based Reasoning form [44] [45], and about particular domain (medical domain). Using a convenient mobile user interface to display the information to patients is an important issue where the exchange of data will be designed to show as a site on the mobile device.

It should be taken into consideration that the proposed prototype does not replace physicians. It actually tries to provide patients or users with some basic medical knowledge about the diagnosis of certain common illnesses.

1.2 Problem Statement

As everybody knows that patients need to have an urgent medical check in case access to a specialist is not available, difficult or unaffordable. This eventually leads to worsening the patients' health condition and makes him/her become unable to receive a proper treatment and medical attention needed on time. Because of this truly serious issue, we propose to design a prototype model which enables patients to enter specific health information through their mobile device. The prototype then provides feedback based on the information given by the patient in a form of a diagnosis and proper advice. This feedback enables patients to make good decisions for any further health checkup or follow up by his/her doctor.

1.3 Motivations and Objectives

1. Build a prototype medical system for diagnosis which should be flexible and easy to use. This prototype aims at helping patients to know about their health condition and make decisions regarding advice or follow up needed.
2. To achieve the desired goals of the proposed prototype mainly providing patients with a remote healthcare and help them make the right decisions regarding their health condition.

3. The prototype can be used as a very effective teaching tool in medical faculties and health institutions.
4. Instead of using DSS in a traditional manner, we can add the concepts and facilities that mobile technologies possess, and implement them in medical fields.
5. It can also be used as an effective learning tool for nursing trainees and medical students in general. This can very much help them do accurate diagnosis, recognize specific symptoms and prescribe proper treatments /medication for common diseases.
6. Study the concepts and characteristics of decision support systems and recognize appropriate methodology that fit the conceptual system functions and achieve the main goal in this thesis.
7. Study the characteristics of mobile technology and identify and determine the cellular communication systems that meet the system requirements and its infrastructure components (software and hardware).

1.4 Solution Approach

1. Identify and state the research problem. Also investigate and analyze the research domain to obtain a solid foundation to address the research problem.
2. Describe the system requirements and determine the design method. In this research work we chose Decision Support Engineering methodology (DSE).
3. Determine the DSS type. In this thesis, Knowledge-Driven DSS meets our system requirements.
4. Clarify the models and techniques used to describe the proposed prototype in all the phases of our suggested methodology.
5. Clarify and describe the knowledge base that is used in the applied part of this thesis. Case Base Reasoning is used to represent the knowledge base.
6. Clarify the mechanism to design user interfaces which can display information on mobile devices as a web site pattern.
7. Finally present a case study to illustrate the proposed approach.

1.5 Structure of Thesis

The remaining chapters of this thesis are organized as follows:

Chapter 2: Presents the background and overview of decision support systems concept, knowledge base, case base reasoning, mobile technology and then the literature survey related to the proposed work.

Chapter 3: Presents the proposed approach or solution which suggests building the prototype. All of the steps of this solution are explained in more detail.

Chapter 4: Presents a case study to show how the various steps of the proposed approach will be applied.

Chapter 5: Presents the concluding remarks, findings and future work.

CHAPTER 2

Background

2.1 Introduction

This chapter presents an overall background of the topics that have significantly influenced the preparation of the present work. This chapter is organized into five sections. In section 2.2 demonstrates an overview of Decision support system (DSS). Section 2.3 gives a quick overview of the knowledge base concepts, and Section 2.4 highlights Case base reasoning the way that is used to represent the knowledge base. A general description of mobile technology is given in Section 2.5. Finally Section 2.6 provides a review of several relevant publications and related works that used as references and motivations to the proposed work.

2.2 Overview of Decision Support System (DSS)

Decision Support System refers to a class of systems that supports business and organizational decision-making activities [1]. And as a view of DSS history it is a subset of computer-based information systems (CBIS) where it consists of a set of information systems such as office automation systems, transaction processing systems, management information systems and management support systems. Management support systems consist of DSS, expert systems and executive information systems, and in 1970 the (CBIS) area began to recognize the important roles information systems play in supporting managers [58] [36]. In the1980s, we witnessed another wave of information technologies, the artificial intelligence-based expert systems (ES), which are to replace and mimic human decision makers in making repetitive decisions in a narrow domain. During the mid-1980s, executive information systems (EIS) emerged as an important tool to serve the information needs of executives. EIS provides timely and critical information which has been filtered and compressed for tracking and control purposes [58].

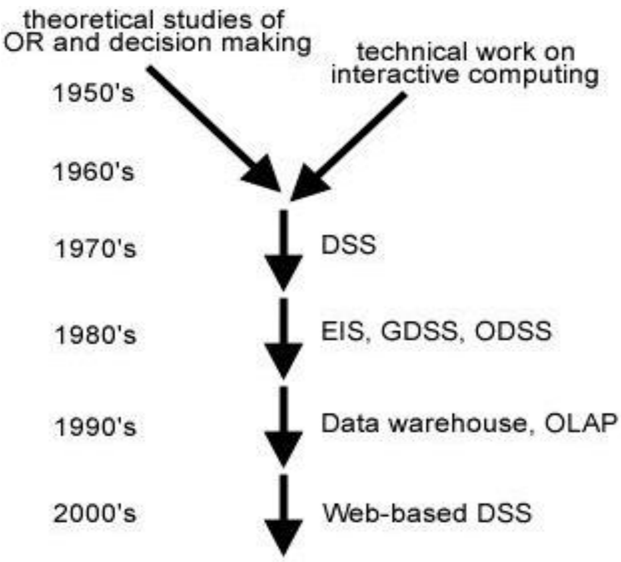

Figure 2.1: Brief history of DSS [36].

2.2.1 Decision Support System Definition

The concept of a decision support system (DSS) is extremely broad and definitions depending on the author's point of view. The following are some of the DSS definitions from different authors.

The general expiration of DSS by **Sprarague** [15][16] "is a specific kind of computer-based information system which helps decision makers confronts ill-structured problems through direct interaction with data and analysis models".

"DSS is intended to help decision makers use communications technologies, data, documents, knowledge and models to complete decision process tasks "[1]. **Turban** [15][18] defines it as "an interactive, flexible, and adaptable computer-based information system, especially developed for supporting the solution of a non-structured management problem for improved decision making. It utilizes data, provides an easy-to- use interface, and allows for the decision maker's own insights".

According to **Little**, DSS is defined as "a model-based set of procedures for processing data and judgment to assist a manager in decision making" [19].

Moore and **Chang** defines DSS as “extendable systems capable of supporting ad hoc data analysis and decision modeling, oriented towards future planning and used at irregular, unplanned intervals” [19].

Bonczek et al defines a DSS as “computer-based systems consisting of three interacting components: a language, a knowledge system and a problem processing system” [19].

In other words, we can state that DSS help people make decisions by providing them with the suitable and useful information which are collected from raw data, documents, personal knowledge, or business models to identify and solve problems and make decisions.

Decision support systems have another equal term which is sometimes used as a synonym for DSS is knowledge-based systems, they were named like that because they need knowledge for building them [2].

2.2.2 Decision Support System Life Cycle

As we know every system has own life-cycle, and the life-cycle terms is a series of stages that are worked through during a specific development [50], in another word is a basic framework which presents the actives for development methodology [51], and the traditional life cycle models present the different life phases in the system and sometimes are defined as the used methods.

Waterfall diagram and liner life cycle drawn by **Boehm** are the most frequently used to describe the systems’ life-cycle. According to **P**.**Zarae** and **C.Rosenthal-Sabroux** [52] we see the life cycle used in DSS is a mixture of liner life cycle based on waterfall diagram.

It should note that life cycle process is used only to describe Decision support systems, Knowledge based systems and Intelligence decision support systems [50].

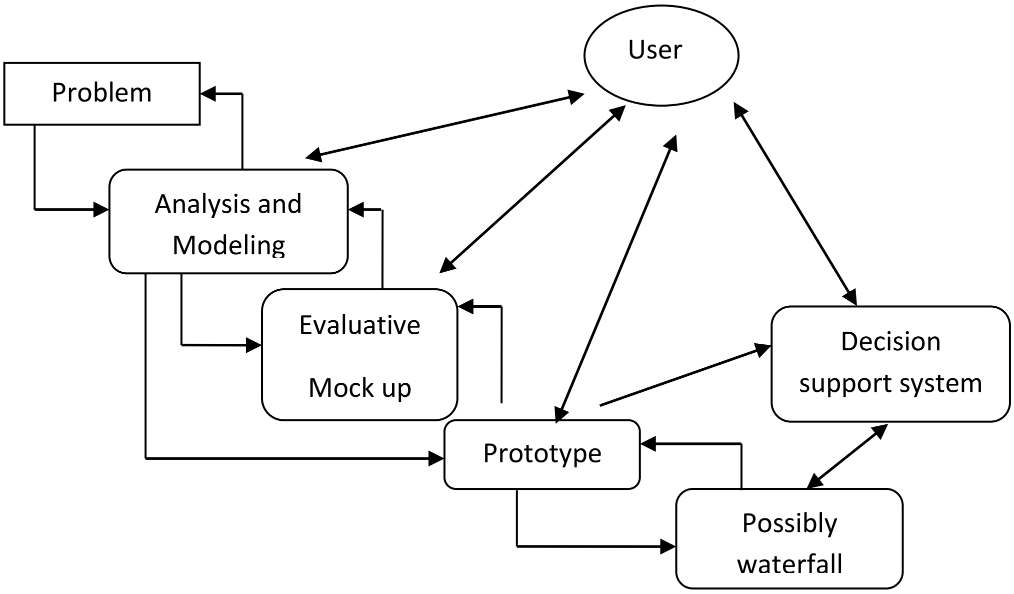

Figure 2.2: DSS life cycle process [52].

2.2.3 The Benefits of DSS

According to [1] [19] the benefits of DSS are as follows:

- Solving problems by providing a decision-maker with information about similar decisions made in the past.
- Assists decision-makers to decide faster with less chance of error.
- DSS has the ability to support the solutions of complex problems.
- DSS consist of the ES (Expert System) component which provides us with a new insight in learning or training.

2.2.4 Components of DSS [37][38][36][58]

Even though different authors identify the components of a DSS, **Sprague and Carlson** in (**1982**) identify three fundamental components of DSS**:**

1. Data base management system (**DBMS**).
2. Model-base management system (**MBMS**).
3. Dialogue generation and management system (**DGMS**).

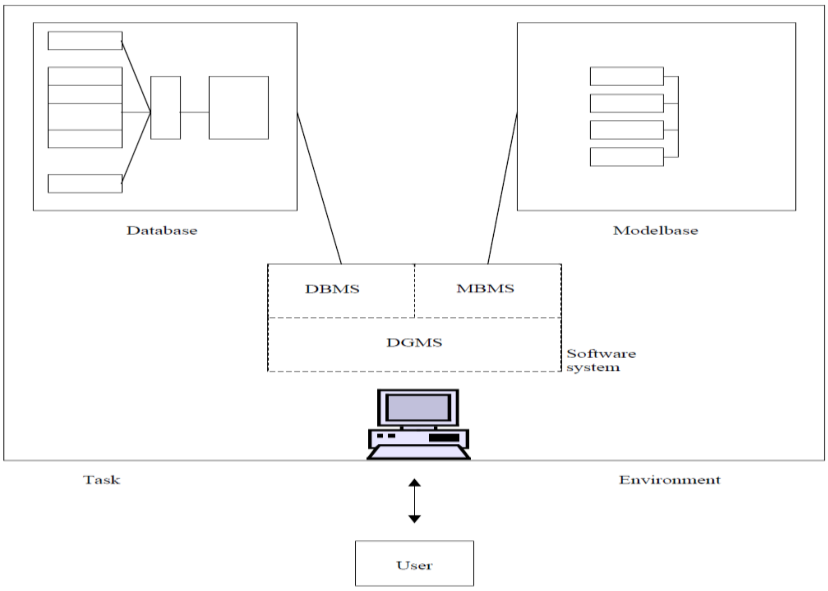

Figure 2.3: DSS components (Sprague and Carlson, 1982) [58].

Power in (2003), building DSS should include four major components:

1. User interface.
2. Data base.
3. Model and analytical tools.
4. DSS architecture and network.

Marakas in (1999) and **Uran** in (2002) proposed a generalized architecture consisting of five distinct parts:

1. Data management system.
2. Model management system.
3. Knowledge engine.
4. User interface.
5. User.

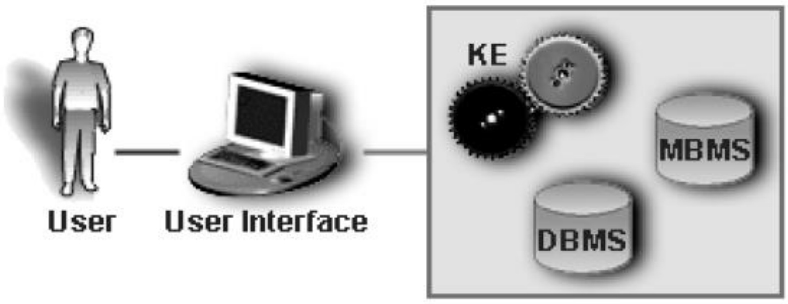

Figure 2.4: The five distinct components of a DSS [36].

2.2.5 Characteristics and Capabilities of DSS

The general characteristics according to **Efraim**, **T., Jay E.A** in (2001) are flexible, adaptive, interactive, GUI (graphical user interface) based, iterative and employs modeling[19], and according to [53] we can list the DSS characteristics as in the following:

1. A DSS provides support for decision makers at all management levels, by bringing together human judgments and objective information.
2. A DSS supports several interdependent and/or sequential decisions.
3. A DSS supports all phases of the decision-making process-intelligence, design, choice, and implementation.
4. A DSS is adaptable by the user over time to deal with changing conditions.
5. A DSS is easy to construct and use in many cases.
6. A DSS promotes learning, which leads to new demands and refinement of the current application
7. A DSS usually utilizes quantitative models.
8. Advanced DSS are equipped with a knowledge management component that allows the efficient and effective solution of very complex problems.
9. A DSS allows the easy execution of sensitivity analyses.

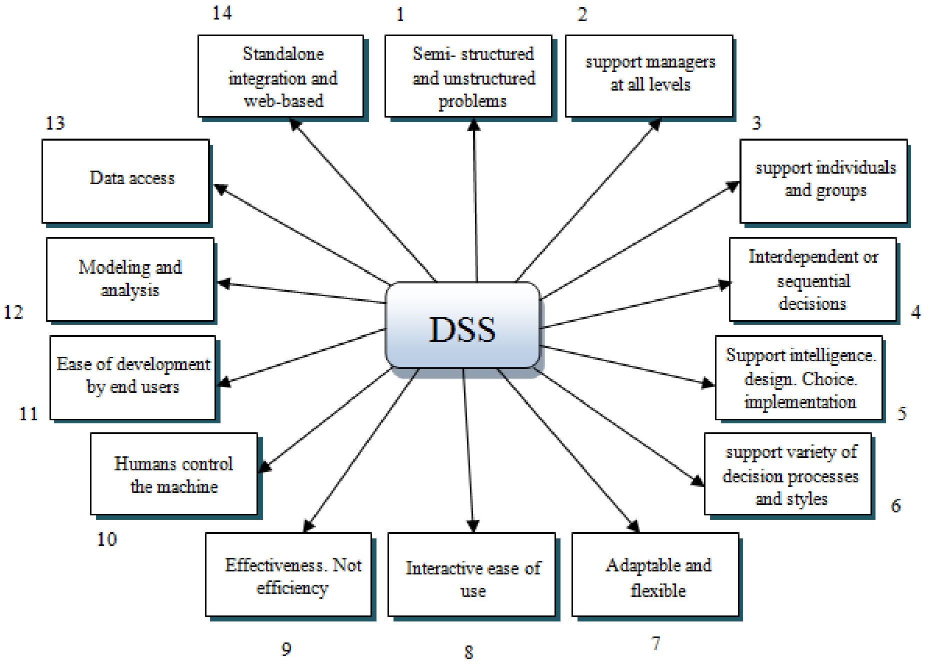

Figure 2.5: Characteristics and capabilities of DSS [19].

In our study of DSS we look at the importance of these concepts like decision-making process and decision maker. According to [21] decision-making "is a process that chooses a preferred option or a course of actions from among a set of alternatives on the basis of given criteria or strategies". According to **Harris** in 1980 [22] [32] Decision Making "is the study of identifying and choosing alternatives based on values and preferences of the decision maker". Making a decision implies that there are alternative choices to be considered, and in such a case we want not only to identify as many of these alternatives as possible, but most importantly to choose the one that best fits with our goals, objectives, desires and values.

According to [23] and **Simons** decision-making model in 1961 and **Youngin** in 1995 the decision-making process composed of four phases:

- Intelligence.
- Design.
- Choice.
- Implementation.

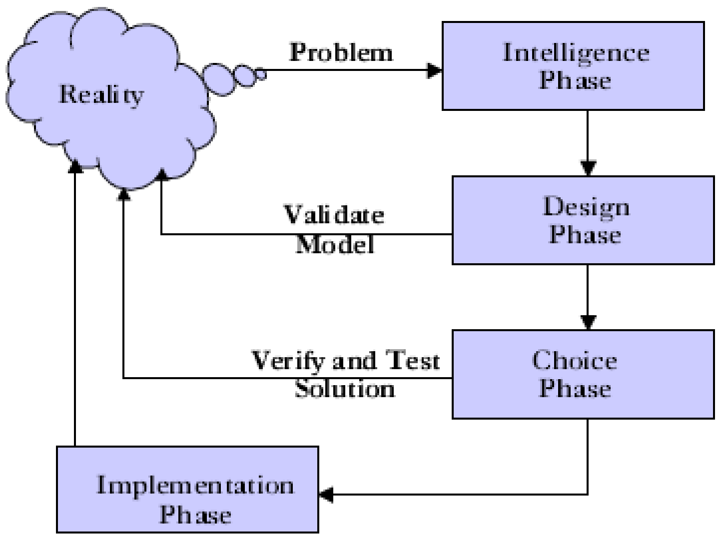

Figure 2.6: The decision making/ Modeling process [23].

A decision-maker: a rough definition of decision-maker is the person who has expertise and has knowledge about a specific domain and understanding of problems that related to this domain, and skilled at solving problems. The decision maker should be reactive and able to confront changing conditions quickly to adapt and meet these changes. (**Dutton** & **Duncan**, 1987) [17].

2.2.6 Types of DSS

The design process, operation and implementation of DSS depend on the type of DSS involved, and there are five types of DSS according to [1] [19]:

- **Communication-driven and group DSS (GDSS)**: This type supports more than one person that working on the same task and many collaborators work together to come up with a series of decisions to set a best solution or strategy. Most communications driven DSS are targeted at internal teams, including partners, and the most commons technology used to deploy the DSS is a web or a client server.
- **Data-driven DSS**: Data driven DSS focuses on collecting data that match the decision maker's needs. This data can be internal, external and in a variety of formats. This model emphasizes access to and manipulation of a series of internal company data and sometimes external and real time data. Most data driven DSS are targeted at managers, staff and also product / service suppliers. It is used to query a database or data warehouse to seek specific answers for specific purposes. It is deployed via a main frame system, client server link or via web.
- **Document-driven DSS**: Are more common, targeted at large numbers of user groups. The purpose of this decision support system is to search web pages and find documents by using a set of keywords or search terms. This model uses computer storage and processing technologies to provide document retrieval and analysis. This type uses documents in a variety of data type such as text documents, spreadsheets and database records to come up with decisions and manipulate the information to refine strategies. The commonly used technology to set up such decision support systems is via web or a client / server system.
- **Knowledge-driven DSS:** DSS is based on the concept of facts, rules, data mining and management of ES applications and all artificial intelligence. It is essentially used to provide management advice or to choose products or services. Knowledge-driven DSS can suggest or recommend actions to managers. These DSS are person-computer systems with specialized problem-solving expertise. The expertise

consists of knowledge about a particular domain, understanding of problems within that domain, and skill at solving some of these problems.

- **Model-driven DSS**: Are complex systems that help analyze decisions or choose between different options, and use limited data provided by decision makers to aid decision makers in analyzing a situation. This type is used by managers and staff members of a business, or people who interact with the organization, for a number of purposes depending on how the model is set up. These DSS can be deployed via software / hardware in stand-alone PCs, client/server systems or the web.

2.3 Knowledge Base Overview

The term Knowledge is used in all areas of human activities and studies, but here is linked to domains that relevant to computer application. According to [41] it referring to "The fact or condition of knowing something with familiarity gained through experience or association".

Decision support system is a class of computer-based information systems including knowledge based type. These systems aim at supporting decision making activities and helping solve a broad range of organizational problems [1]. We must mention here that the DSS we use in our work is knowledge-driven DSS, so in this section we try to highlight the most important concepts of knowledge base (KB).

2.3.1 Knowledge Engineering

The process of collecting knowledge from experts and other sources to build a knowledge base is called knowledge engineering [41]. Another definition in 1983 by **Edward Feigenbaum**, and **Pamela McCorduck KE** is " an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise "[54], and used in many different domains such as database, data mining, expert system and decision support system [54]. According to **Feigenbaum** and **McCorduck** in (1983) [41] [52] the activity of building knowledge engineering is defined in the following steps:

- **Knowledge Acquisition**: Is the first process or phase of knowledge base building in which acquired knowledge is collected to be used in the next step (Knowledge Representation), the required information collected by using sources and method such as:
    - Interviews with experts in the problem domain and users who have previous experience in using similar systems.
    - Documents and data base in the domain problem.
    - Obtain and collect information from system users by using Brainstorm mechanism.
- **Knowledge Representation:** After acquiring knowledge from different sources, the next step is to represent the knowledge and identify the methods to be used. We also have to decide which methods convenient depending on the nature of the knowledge and the efficiency of its use [41]. The most common methods of knowledge representation are [55]:
    - Predicate logic.
    - Production rules.
    - Frames (objects) and semantic networks.
    - Conventional programs.
    - Cased based reasoning (we will describe in Section 2.5).
- **Knowledge Validation:** Involves validating and verifying the knowledge by using test cases and showing the test result to expert domain.
- **Inference:** This step involves enabling the computer to make inferences based on the stored knowledge and the specifics of each problem by designing suitable software. There are three techniques used when inference the facts from knowledge [56]:
    - Forward changing.
    - Backward changing.
    - Hybrid using of Forward changing and Backward changing.
- **Explanation and Justification:** This step is mainly concerned with the design and the programming of an explanation capability (e.g., programming the ability to answer questions such as why a specific piece of information is needed by the computer or how a certain conclusion was derived by the computer).

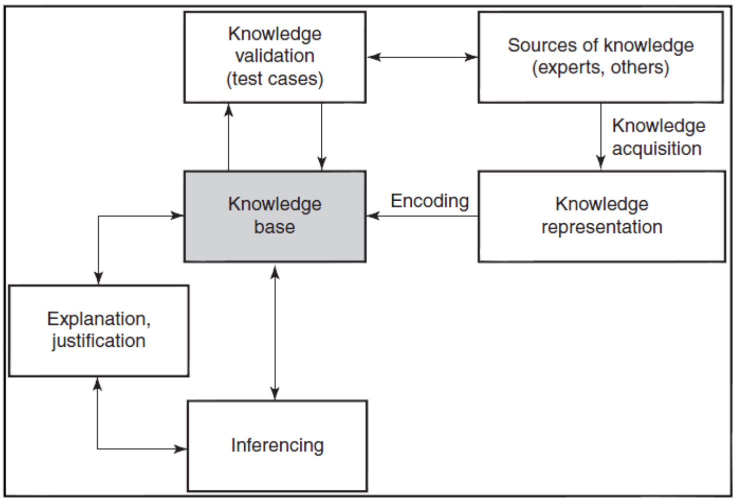

Figure 2.7: knowledge engineering process [41].

2.4 Overview of Case Based Reasoning

In 1977 ***Schank*** and ***Abelson*** have a wide work for origins of CBR and the first system that named a case-based reasoning was the CYRUS system, developed by ***Janet Kolodner*** in 1983 [42][43]. As we know that knowledge-based systems (KBS) are one of the most well-known success stories in the field artificial intelligence (AI) research. Many (KBS) developers confront several challenges such as knowledge elicitation process and implementing KBS, which is in fact a difficult process and requiring special skills [42]. To tackle such complex issues developers used several techniques and tools such as shells and knowledge modeling languages and ontology, however case-based reasoning (CBR) solves these problems by adapting previously successful solutions to similar problems. It is important to know that CBR refers to specific knowledge of similar experienced situations or cases, which can deal with complex and unstructured problems and it is easy to update the knowledge base [46]. For these reasons CBR has been commonly applied in many areas where CBR systems have been used in a wide variety of fields and applications such as medical [47].

2.4.1 Case Based Reasoning Definitions

The term CBR mainly refers to the concepts which are used to solve problems by adapting solutions that were used to solve previous problems that similar to current problems. In fact, the general concept of CBR was given different definitions by many authors. Numbers of these definitions were classical and broad. For example, ***Riesbeck and Schank*** who defined CBR as "A case-based reasoning which solves problems by using or adapting solutions to old problems" [44]. CBR" is an important paradigm of artificial intelligence mainly used for problem-solving" [46].

CBR "is a methodology for solving problems by utilizing previous experiences. It involves retaining a memory of previous problems and their solutions and, by referencing these solve new problems" [45]. And according to [46] Case Base Reasoning "is a reasoning methodology that reuses past cases to find a solution to the new problem and is preferred for ill-structured managerial decisions".

2.4.2 Case Based Reasoning Life Cycle

As we previously mentioned that the basic idea behind using CBR is to solve a new problem by remembering and reusing information from a previous similar experience. To achieve this tend there are steps or process called CBR cycle [47] [48]. Figure 2.8 illustrates the CBR life cycle, According to [44] [46] [47] [48] the cyclic process of CBR includes five phases:

1. Retrieve Phase: It is the most important phase of the cycle. It consists of measuring the similarity of the current problem to previous problems for retrieving the most similar cases. This process is based on using the similarity metrics. There are multiple measures which can be used in this phase, the most popular being the method of the k-nearest neighbors. The most similar case or cases [48] [49]:

$$Similarity\ (C,S\ )\sum_{f=1}^{n} w_f * sim(C_f\ ,S_f)$$

Where C is a current case, S is a stored case in the case base, w is the normalized weight, n is the number of the attributes/features in each case, f is the index for an individual attribute/feature and sim (C_f, S_f) is the local similarity function for attribute f in cases C and S.

$$w_f = \frac{lw_f}{\sum_{i=0}^{n} lw_f}$$

Here, a Local weight (lw) is defined by experts, assumed to be a quantity reflecting importance of the corresponding feature, (w) is Normalized weight.

2. Reuse Phase: In this step the information and knowledge about the required case is adapting (if need be) to solve the problem.

3. Revise Phase: The proposed solution is presented to the user who will decide on his validity.

4. Retain Phase: It consists of adding the new problem with its solution to the case base. This eventually enables the system learns from its experiences.

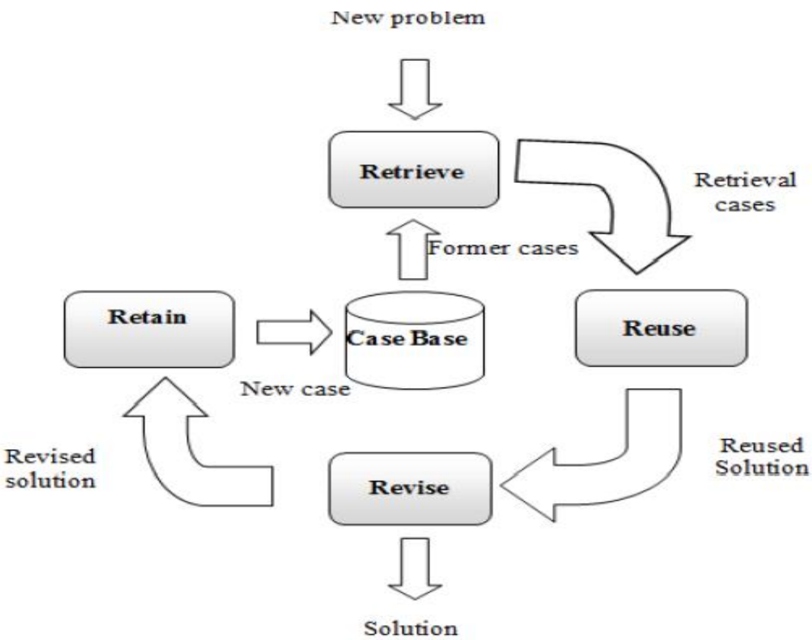

Figure 2.8: CBR life cycle [48].

2.5 Introduction of Mobile Technology

For the last decade, the field of mobile technology has been witnessing a significant and rapid development and eventually became more and more integral part of our everyday lives. As it is known for all that the wireless revolution has transformed mobile communication from only voice with relatively static into extensible. Internet-enabled communication with advanced data and software support [6]. The adoption of mobile computing has very much changed our life style from the desktop to mobile environment.

This resulted in giving more powerful, versatile and pervasive capability to handheld devices. It also has made an inevitable change in the way we work, study and communicate. This change has helped increase the capabilities of PDAs and smart phones and enabled these devices to be used for a wide variety of tasks and applications.

Mobile Computing" is a technology that allows transmission of data, via a computer without having to be connected to a fixed physical link" [7] [8], and according to [9] [14] the term Mobile computing "is a generic term that refers to technologies that allow you to take your computer with you, and used to describe the use of computing devices, which interact in some way with a central information system that is away from the fixed workplace". Simply Mobile Computing technology enables the mobile users and workers to create, access, process, store and communicate information without being constrained to a specific location.

Since the 1960s and according to [10], there have been four major cycles of computing mainframes, mini computing, personal computing, and desktop computing. Mobile computing, the 5th technology cycle, is predicted to have a far greater impact and adoption than any of the previous cycles.

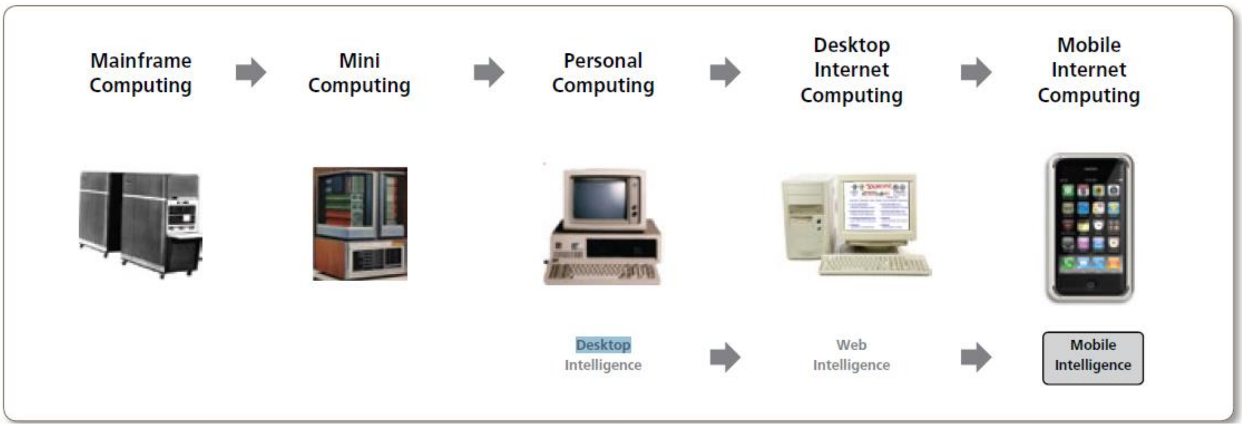

Figure 2.9: Major cycles of computing mainframes [10].

The mobile devices are commonly known as a mobile phone, a cellular phone, a cell phone and a hand phone. The simple definition of a mobile phone "is a device that can make and receive telephone calls over a radio link whilst moving around a wide geographic area". It does by connecting to a cellular network provided by a mobile phone operator, allowing access to the public telephone network. By contrast, a cordless telephone is used [12][13], some examples of mobile devices [14]:

- Laptop and notebook computers.
- Palmtop computers or personal digital assistants.
- Mobile phones and 'smart phones.
- Global positioning system (GPS) devices.

Any mobile phones such as cell phones, PDAs or smart phones have certain characteristics which are evolving differently in many brands. For example, battery life has improved, screens always small, low power, processors and memory cheaper, less power and improved input methods like the Virtual key. In the same time, these devices have limited capabilities such as memory requirements, computational power and user interaction with these mobile devices when reading from a small screen in an environment with poor lightning becomes a big hassle. The most important advantage of cell phones is that they can be used almost everywhere without cables or the need for sockets, and can communicate with anyone whenever and wherever.

Users can interact with the service providers through a mobile and wireless network, using mobile devices for information retrieval and transaction processing [11], and these service like, Messaging (SMS, MMS, GPRS), email, packet switching, WAP and Bluetooth.

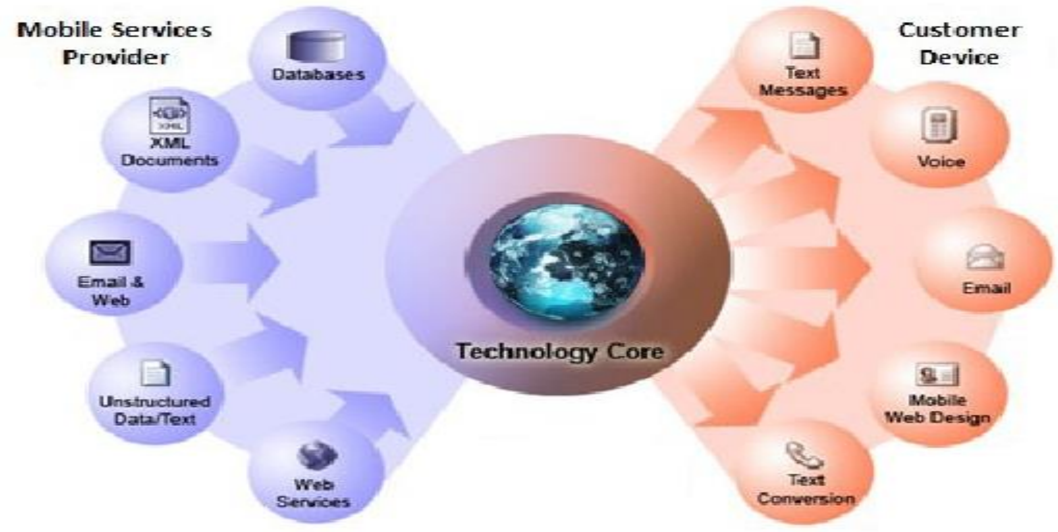

Figure 2.10: Mobile computing services [14].

2.5.1 Characteristics of Mobile Computing [8]

Mobile computing is a combination of computer hardware system, applications software and communications medium.

- **Hardware**: The characteristics of mobile computing hardware are defined by the size, form, factor, weight, microprocessor, primary storage, secondary storage, screen size, battery life, communications capabilities, expandability and durability.
- **Software:** The most common system software and operating environments used on mobile computers includes MSDOS, Windows 3.1/3.11/95/98/NT, and UNIX, android.
- **Communication:** There are many communications technologies that enable mobile computers to keep in touch. The most popular technologies are :
    - Wireless Local Area Networks (WLANs).
    - Satellite.
    - Cellular Digital Packet Data (CDPD).
    - Personal Communications Systems (PCS).
    - Global System for Mobile communications (GSM).
    - RAM and ARDIS data networks.

2.5.2 The Advantages of Mobile Computing [8][35]

- Creating an information management platform that allows users to access and process desired information from anywhere.
- Increasing **Productivity**: Mobile devices can be used out in the field of various companies, less time and lower cost for those companies and their clients.
- **Entertainment**: Mobile devices offer an infinite set of entertainment applications and tools for different ages and cultures.
- **Portability**: This is one of the main advantages of mobile computing. As the term suggests that you are not restricted to one location in order to get jobs done or even access email on the go.
- **Cloud Computing**: This service is available for saving documents on an online server and allows accessing to those files on several mobile devices or even PCs at home anytime and anywhere as long as access to Internet connection is available.

2.5.3 Limitations of Mobile Services [8] [35]

- **Insufficient Bandwidth**: Mobile Internet access is slower than direct cable connections, as using technologies such as GPRS, EDGE, and 3G networks have very limited range.
- **Security Standards:** Security is a major concern. As we know that connecting to public networks requires careful use of Virtual Private Network (VPN). This lead in some cases enables anyone to easily attack the VPN through a huge number of networks interconnected through the line.
- **Power Consumption**: When a power outlet or a portable generator is not available, this affects mobile devices. This means the mobile device must rely entirely on battery power to obtain the necessary battery life.
- **Transmission Interferences**: Transmission interferences like weather, terrain, and the range of signal point can interfere with signal reception.
- **Potential Health Hazards**: There are allegations that cell phone signals may cause health problems.

2.6 Literature Survey

Decision support systems have gained a great deal of popularity in various domains and fields for different purposes and applications. Those systems are used for business, engineering, military fields and most commonly in the medical field for both educational and therapy purposes. In this part we will focus on all applications that use the decision support systems in health care remotely by using wireless or mobile device.

J.Basilakis, N. H. Lovell and S. J. Redmond [24], they presented and described telehealth system by enterprise application-server framework, combined with a rules engine and statistical analysis tools used to analyze the acquired telehealth data. They also searched for trends and shifts in parameter values to reduce the data overload and to provide a means of health risk stratification. This intends to allow appropriate targeting of clinical resources to best manage the health of patients in general.

Y. Anokwa, N. Ribekaand et al [25], they shed light on the importance of using clinical decision support systems (CDSS) to improve patient care in resource-limited settings where the health care is far from the patient and try to connect with health system remotely by using a mobile device. They described the problems and failure modes that can affect the use of CDSS implementations by multi-method approach and building from six iteratively derived design principles.

B. Chakravarti and Dr. S. B .Bhattacharyya [26], their proposal was to use mobile facilities for patients in critical conditions and in need of urgent medical attention. This is to set the availability of the information required including the address of the patient and his /her health history. This helps in bringing out the solution architecture to be used by healthcare provider and have full control of his patient 'data along with alerts. It also suggests possible clinical decision support through pre-set rules and possible knowledge discovery.

M.k.Lin, J.M. Mula, R. Gururajan, and J.W. Leis [27], presented development of a multi-touch measuring tool for a Mobile Electrocardiography (ECG) telehealth decision support system (DSS) prototype, which is capable of providing remote mobile communication to speed up diagnostic decision making. The prototype developed was able to display three dimensional multi-layers on a mobile device such as a smart phone extracting ECG information from a web server. Users could have access to the mobile (ECG) decision support system whether their hand-held device runs Android OS, iPhone iOS and Window Mobile OS or any other multi-touch screen smart phone.

J. Nièsact, I. Colombet and et al [28], focused on clinical decision support systems that automatically provide the clinician with electronically formatted recommendations and identify the features of systems from published data. It also intended to identify the methodological characteristics of studies and the technical characteristics of (CCDSSs) associated with efficacy.

M.S. Chalga and A.K Dixit [29], developed a Decision Support System (DSS) which incorporates Interactive Voice Response System (IVRS) to collect information from health workers through their mobiles. They also presented software modules to update data from IVRS to Database server automatically and system web site. This web site generates dynamic online reports from Database server for the perusal of health. The system has been developed for the existing health functionaries and attempted to develop a real time health management information system by using mobile technology.

D. DZEMYDIENEa and R.DZINDZALIETA [30], they presented the technological platform to aggregate sensor components integrated with mobile technology. Those components can support the online processing of real data for localization and monitoring of transport objects and allow online recognition of abnormal situations. The platform describes a general component model that is a basis for dangerous good transportation and expressing properties of knowledge of domain for informational structure specification.

R. Meredith, G. Shanks and et al [34], proposed a model for mobile decision support which aims at helping nurses in determining treatment category of patients. The proposed model integrates soft computing and mobile computing technologies to provide intelligent decision support which leads to the implementation of the model.

CHAPTER 3

Designing a Prototype Model for Mobile Disease Diagnosis

3.1 Introduction

The focus of the previous chapters was mainly on the decision support systems and mobile computing characteristics. This chapter presents and describes in detail the proposed solution that we used to build the required prototype. The proposed approach is based on using Decision Support Engineering methodology (DSE), with mobile technology. Section 3.2 presents an overview of a general architecture for building the proposed prototype. Section 3.3 presents in detail the DSE' stages, models and techniques that are being used in each phase of building prototype.

3.2 Overview of a General Prototype

The proposed prototype is based on the DSS concepts (see Section 2.2 in Chapter 2) and using the characteristics of mobile computing (as given in Section 2.5 in Chapter 2). The presented study follows the DSE methodology to analyze and design the prototype for building the system diagnoses. To implement the prototype, a mobile device is used as user interfaces to enable the patient connect with the system anytime and anywhere. The symptoms of each disease have to be categorized according to specialty such as abdominal, cardiac diseases, kidney, bones aches, and cancers, general and joint infections. The planned prototype should be:

- Easy and applicable, in all methodology stages.
- Clarifies the system functions and features.
- Meets the needs of the patient and provide the required medical services in a timely manner.
- Provides an easy and remote assistance and diagnosis as the user has a mobile phone/device connected to internet service.

3.3 Decision Support Engineering Methodology (DSE)

Decision Support Engineering (DSE) is a methodology used to describe the stages that DSS have [20]. The DSE methodology gives an insight of all the functions and operations in the system. We use this methodology for many reasons [20]:

- ✓ DSE is a comprehensive methodology based on using the life cycle model of decision support systems and engineering approach.
- ✓ This approach assumes the functionality of DSS and achieves the negotiation between user and builder.
- ✓ Focuses on the support provided by DSS development.
- ✓ Has been used in a number of DSS projects.

The DSE Methodology consists of five stages. Each stage presents a step in DSS life cycle and is mainly achieved by using suitable models and techniques. Figure 3.1 shows the main stages in DSE methodology and Figure 3.2 shows the sub stage in each stage.

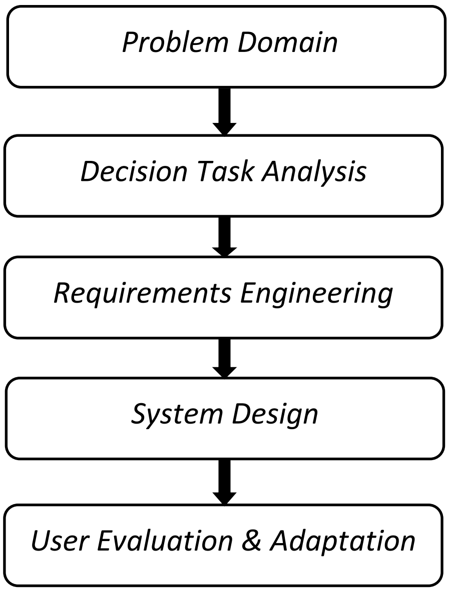

Figure: 3.1: The main stages in DSE methodology adopted from [20].

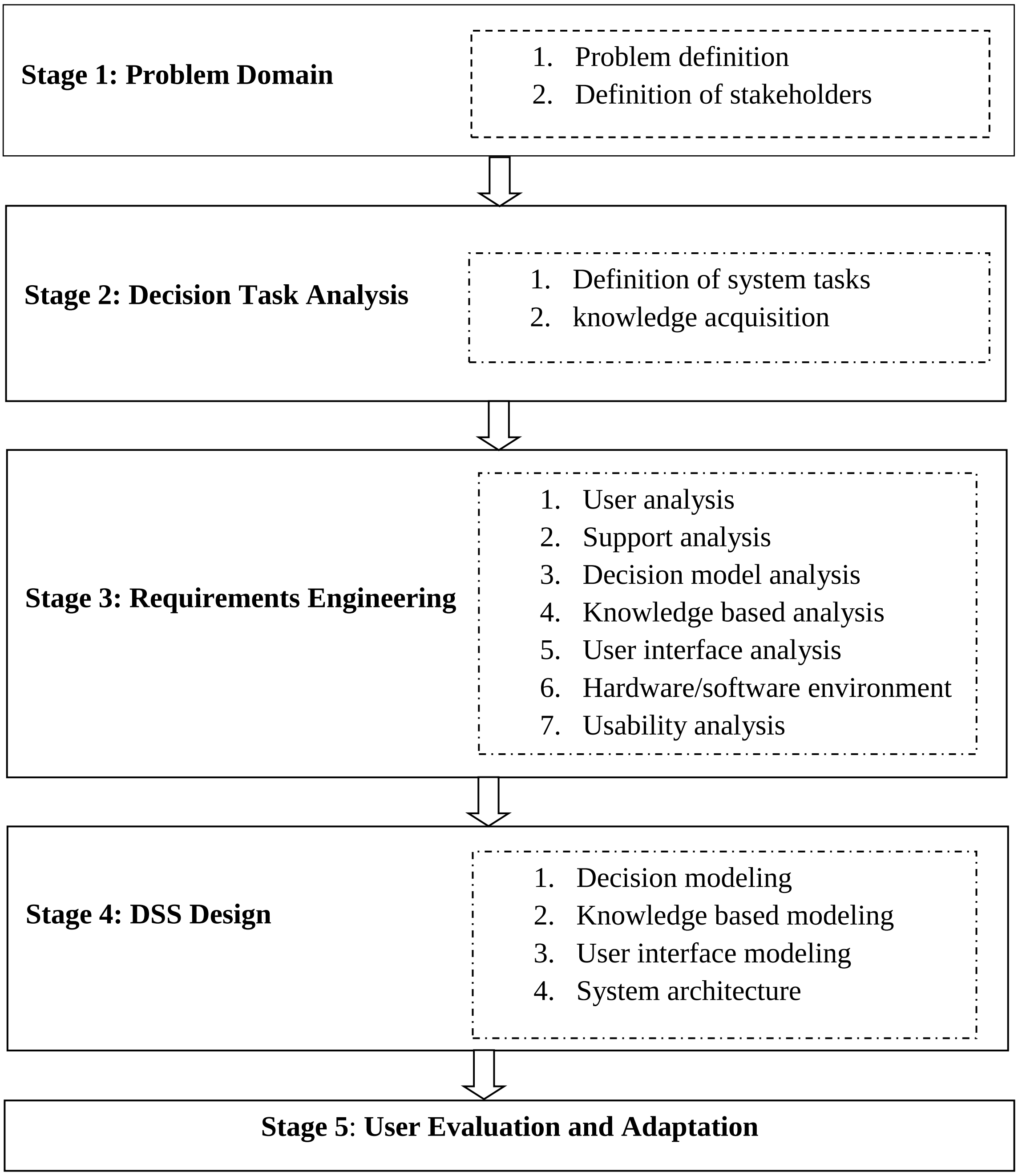

Figure 3.2: The sub stages of DSE methodology adopted from [20].

3.3.1 Stage 1: Problem Domain

This is the first stage and considered as an essential step because it basically relies on real understanding and a clear definition of the problem. This leads us to focus on our work and the next stages and finally build the required prototype. We have to clarify the benefits of building the system, and also identify the stakeholders or actors that interact with the system. In this stage the stakeholders being identified are in subsection 3.3.1.1.

3.3.1.1 Definition of Stakeholders

As we know a stakeholder "is any person who has a relationship or interacts with the system. The stakeholder can be technical or nontechnical workers, they may also include both internal and external workers" [59]. Table 3.1: illustrates Stakeholders' identification, the table consists of three fields:

- **Stakeholder _ ID**: This filed gives the stakeholder a unique number or ID.
- **Stakeholder _ Name**: Every stakeholder interacts with the system has a name .The name refers to the function performed or the relationship to the system.
- **Functionality:** This field determines and explains the nature of the relationship of users with the system, while the stakeholder maybe an end-user using the system and functions. A stakeholder could also be an administrator who is responsible of maintenance side or sometimes an expert who helps build the knowledge base. Table 3.1 illustrates the stakeholders' identification.

Stakeholder _ID	Stakeholder _ Name	Functionality

Table 3.1: Stakeholders' identification.

3.3.2 Stage 2: Decision Task Analysis

At this stage the following steps are taken:

3.3.2.1 Definition of System Tasks

Identify the tasks that the system performed in general and the tasks that associated with decision processing. In some cases, the complex tasks should be decomposed into sub tasks in order to facilitate and clarify the process of building a model. In the context of the stated methodology, we will use the scenarios that describe the tasks which the system performs. We can use visual models to clarify these scenarios like flow chart and UML models. In this step, the use case model we are going to use to describe the system tasks are shown in Figure 3.3.

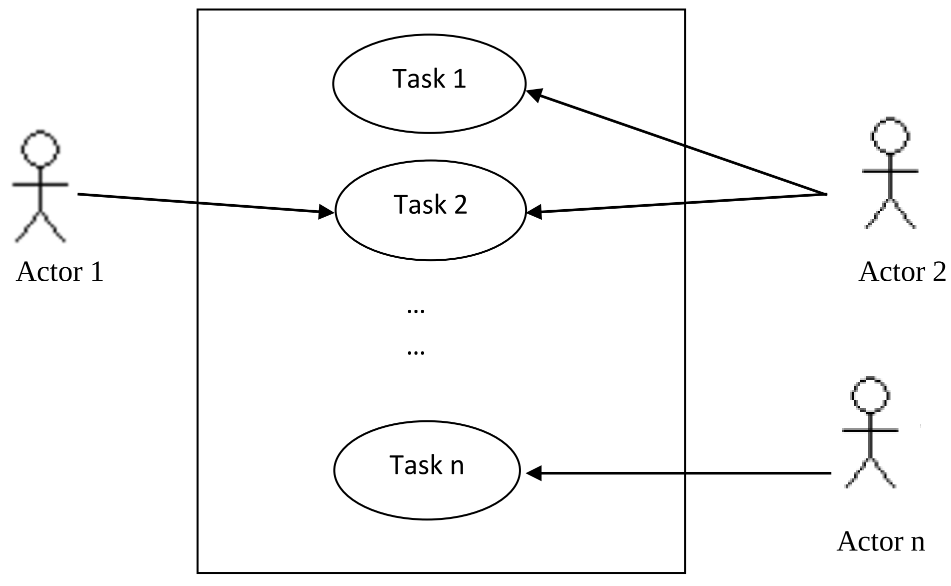

Figure 3.3: Use case model of the system tasks.

As we see in Figure 3.3 the use case model shows interaction between one or more persons called actors (or stakeholder) and system tasks. Each actor is associated with one or more use cases (system tasks). We can use the next table to clarify each task in the system with more details. Table 3.2 shows the use case documentation of the system tasks.

Task name/ use case name	
Actor	
Pre-condition	
Post-condition	
Short Description	< Brief description of use cases>

Table 3.2: Use case documentation of the system tasks.

Use cases represent the functions of the system. ***Actor*** is a person who interacts with the system, the ***pre-condition*** statement indicates what must be true before the function is called, and the ***post-condition*** statement indicates what will be true when the function finishes its work [65].

3.3.2.2 Knowledge Acquisition

There are several ways to collect the data to build a knowledge base such as interviews with users by asking direct questions. In our work we used ***brainstorming*** *method* with actors like doctors. We can also use medical reports and documents related to the proposed system. ***Brainstorming*** "is using a group of creativity technique to gather and collect all ideas about a specific problem" [57].

3.3.3 Stage 3: Requirements Engineering

The importance of engineering requirements is to identify the functionality and performance of DSS characteristics and mobile which is supposed to lead to decision process [20].

This stage includes:

1. User Analysis.
2. Support Analysis.
3. Decision Model Analysis.
4. Knowledge Base Analysis.
5. User Interface Analysis.

6. Hardware/ Software Environment.
7. Usability Analysis.

3.3.3.1 User Analysis

A deep analysis of the knowledge the users have is very important. Competence and experience among users of this type of systems help determine the requirements and the scope of the system. Based on the answers given by the users, the engineering expert can create a background on the borders of the system and components, for example the users' experiences of the suggested system and the extent of their knowledge of previous similar systems. Is there a need for trainers or experts to deal with system? Do all the users have enough information about the techniques that are used in the proposed system? To summarize this stage we use Table 3.3 to explain the amount of user's knowledge of the proposed system. Table 3.3: Analysis of user's knowledge.

<table>
<tr><th>User_ Name</th><th colspan="2">Degree of Knowledge</th><th>Recommendation</th></tr>
<tr><td rowspan="3"></td><td>Experience with Mobile</td><td rowspan="3">degree of knowledge</td><td rowspan="3"></td></tr>
<tr><td>Experience with DSS type</td></tr>
<tr><td>Training in DSS</td></tr>
</table>

Table 3.3: Analysis of user's knowledge.

Having looked at the last tables, there are three fields to consider:

- **User_ Name**: This field states the name of the user who interacts with the system.
- **Degree of Knowledge:** This field shows a specified level of knowledge depending on the users and their relationships with the system .There are criteria tools which help assess the level of competence among different users:
    - **Experience with Mobile** :none, little, sufficient
    - **Experience with DSS type**: none, little, sufficient.
    - **Training in DSS**: trained, untrained.
- **Recommendation:** Conditions must be available among users.

3.3.3.2 Support Analysis

System users have their own perception or expectations of the extent of the support provided by the proposed system. In other words, the support analysis is a sub stage at which users become acquainted with the facilities and the support the system provides. This is done through scenarios such as prototypes or interviews or negotiation between users and builders of system. These scenarios give the developers a good starting point of about the extent of expectations among users. The outcomes of this sub stage are a set of objectives of the proposed system and clarification of the support expected. We present this sub stage by using ***paper prototyping*** *"paper prototyping is a process that helps developers to create software that meets the user's expectations and needs"* [66].

3.3.3.3 Decision Model Analysis

The objective of this sub stage is to determine the appropriate technique in order to describe the decision task and most importantly have a clear decision process by using the visual model. The decision task depends on using the cases stored in knowledge base to generate a required decision. In this context, the patient enters the data into the system by using mobile UI then the system analyzes data through the knowledge base .This generates query relying on the stored information (cases). After comparing the entered data with the knowledge base, a decision is to be made through selecting a matching status. Figure 3.4 illustrates the conceptual model of decision task, and Figure 3.5 illustrates the simplified algorithm for decision task process.

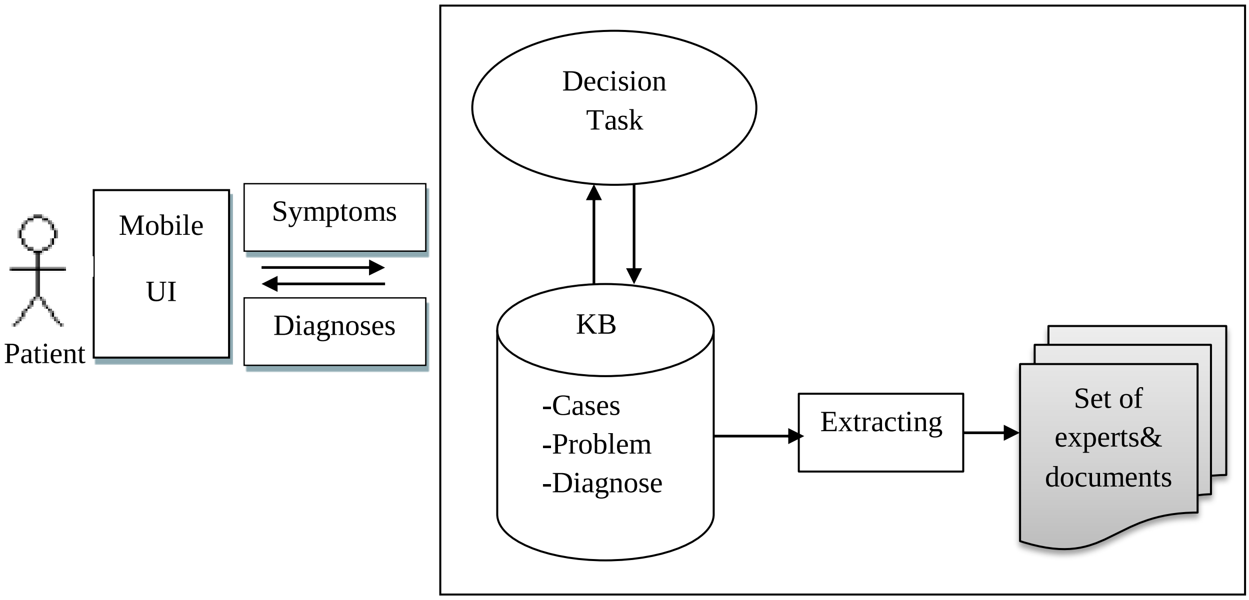

Figure 3.4: Conceptual model of decision task.

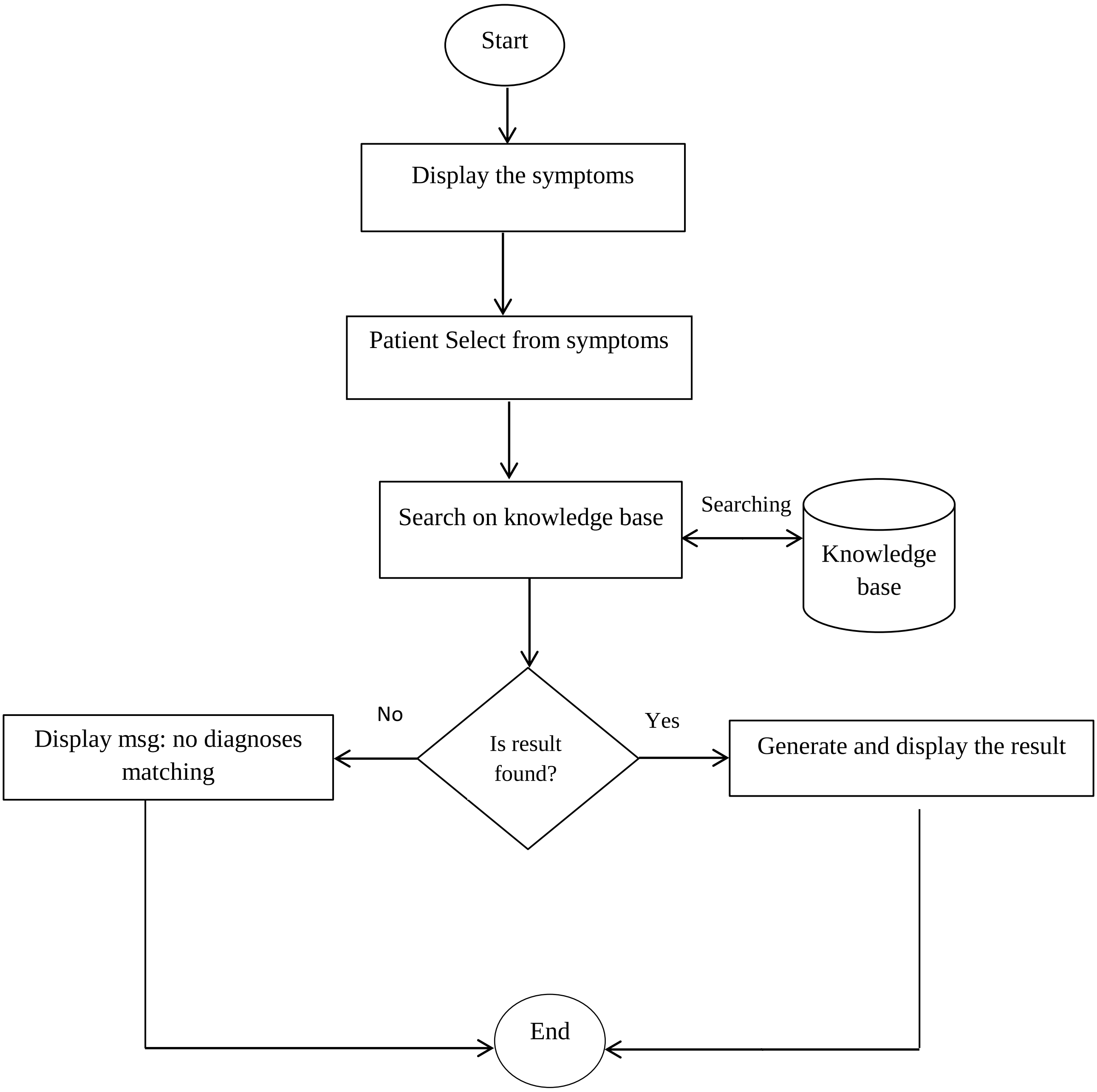

Figure 3.5: Decision process algorithm.

The description of the last algorithm is as follows:

1. The system displays a list of symptoms of each disease on the mobile screen. This list of symptoms is prepared by an expert in this domain.
2. The end-user or the patient chooses the symptoms which match his/her health condition.
3. Based on the symptoms which the user chooses, the system begins the processing the diagnosis by referring to the saved cases in the knowledge base. Having received the research results, the patient takes his /her decision. The results have two possible outcomes:
    - If the research result of the cases in the knowledge base is not found then the system displays message "no diagnosis matching".
    - If the research for cases in the knowledge base succeeds, then the user/patient is given a matching diagnosis and advice accordingly.

3.3.3.4 Knowledge Base Analysis

As we know knowledge base is not a static collection of information, but it mainly consists of dynamic data, information and interrelationships consequences and predications [41]. This helps build the system and provides the capacity to learn. All of this process is created by the knowledge engineer by conducting a series of interviews with experts .The engineer organizes the knowledge in a form that can be directly used by the system [41]. Notably, knowledge base analysis is a stage which includes analyzing information and knowledge obtained during the knowledge base acquisition and elicitation (see Section 2.3 in Chapter 2). In all stages of building knowledge base, the ***CBR*** method will be used. In fact, this method is considered easy and simple in term of formalizing and updating knowledge base. This method also helps recapitulate previous learning and therefore able to infer new case. There are three steps to build a knowledge base**:**

- **Knowledge Acquisition.**
- **Knowledge Representation.**
- **Knowledge Extraction.**

Figure 3.6 shows the knowledge base building steps. We give a description of these components.

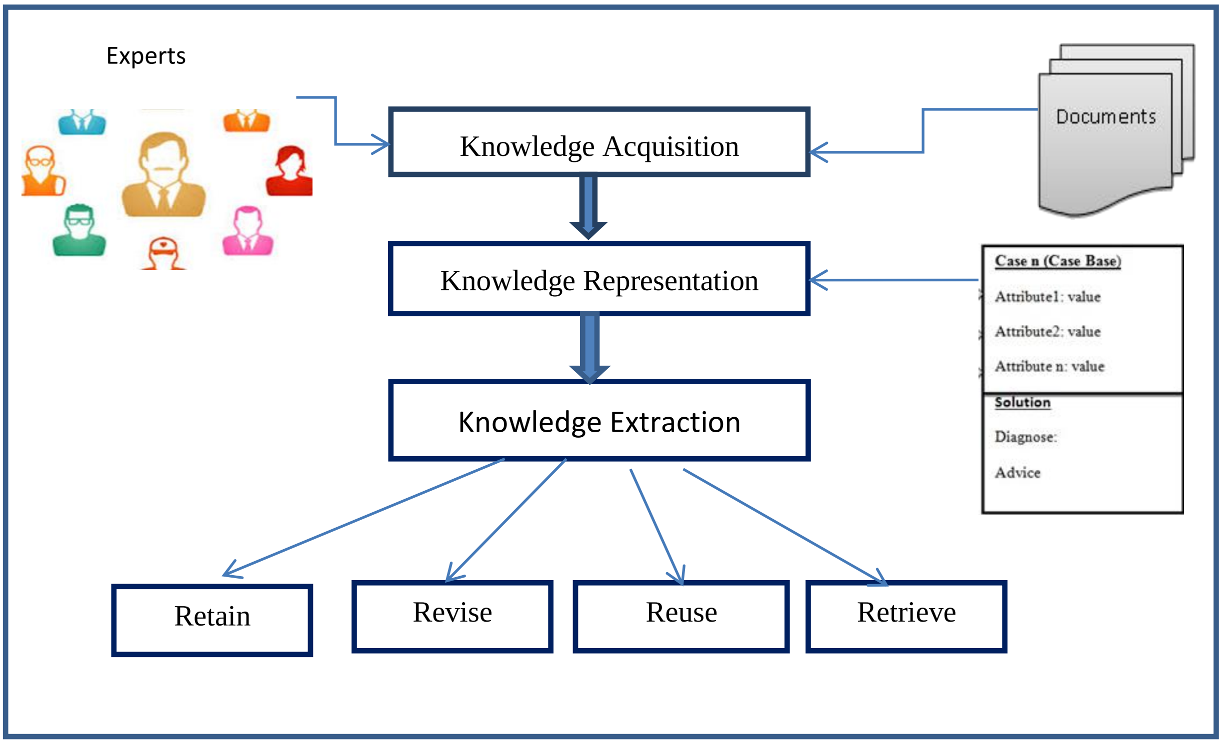

Figure 3.6: Knowledge base building steps.

- **Knowledge Acquisition:** In this step, we collect the knowledge needed to identify the sources and methods to be used in this acquisition process.
- **Knowledge Representation:** After collecting knowledge from different sources, the next step is to represent the knowledge and identify the used methods. It is important to mention that the knowledge base represents as a set of cases and each case is defined as attributes or features. Attributes have their own values and solutions. Each solution consists of diagnosis and advice. Table 3.4 describes the content of each case in knowledge base (case base) and Table 3.5 illustrates the attributes of every single case.

Table name	Content	Data type	Description
Case	Case no	Integer	<case number or ID where every case has a unique number
	Attribute no	Integer	< unique number of each attribute >
	Attribute value	Boolean	<value yes or no for every attribute>
	Diagnoses	Text	<the diagnosis of health conditions >
	Advice	Text	<the medical advice given>

Table 3.4: Description of Case.

Table name	Attribute	
Attribute	**Data type**	**Description**
Attribute no	Integer	< unique number for every Attribute >
Attribute name	Text	< Attribute name >
Attribute value	Boolean	< value yes or no for every attribute >
Importance	Integer	<value prepared by expert for every attribute >

Table 3.5: Description of case attributes.

- **Knowledge Extraction:** In this step, the strategy or the technique used to search in KB and retrieve similar cases is determined. In our case study the ***CBR*** life cycle phases is used to caver this process. These phases include the following:
  - **Retrieving step:** Comparing current case (problem case) with each case in the case base or the knowledge base and retrieve the similar case by using the similarity metrics. Similarity metrics are derived after comparing every factor attribute in current case with a corresponding attribute case in the case base as showing in Figure 3.8 .When the attribute value of the current case equals the attribute value of the stored case ,this means that similarity is 1 if not similarity is 0. Final similarity between the problem case and stored case will be calculated from the following metrics (see Sub section 2.4.2 in Chapter 2).

$$Similarity\ (C, S\ ) \sum_{f=1}^{n} w_f * sim(C_f\ , S_f)$$

$$w_f\ = \frac{lw_f}{\sum_{i=0}^{n} lw_f}$$

After calculating the similarity within metrics in the retrieval process of knowledge base, the values are stored in Table 3.6. There are three possibilities for the recovered case:

- **Possibility 1**: The degree of similarity equals 0. This means the entered case has no diagnosis or advice available.
- **Possibility 2:** The degree of similarity equals 1 which means the entered case is matching to one of the saved cases in the case base.
- **Possibility 3:** The degree of similarity between 0 and 1 in this case, the similar case is selected and therefore saved as a new case.

Table 3.6 shows the similarity values, and the next flowchart described a simplified algorithm to proses the retrieve case in Figure 3.7.

Similarity(C,S_n)	**Value**
<find similarity between problem case with each stored case in knowledge case where C is problem case and S_n is every case in case base >	Integer

Table 3.6: Similarity values.

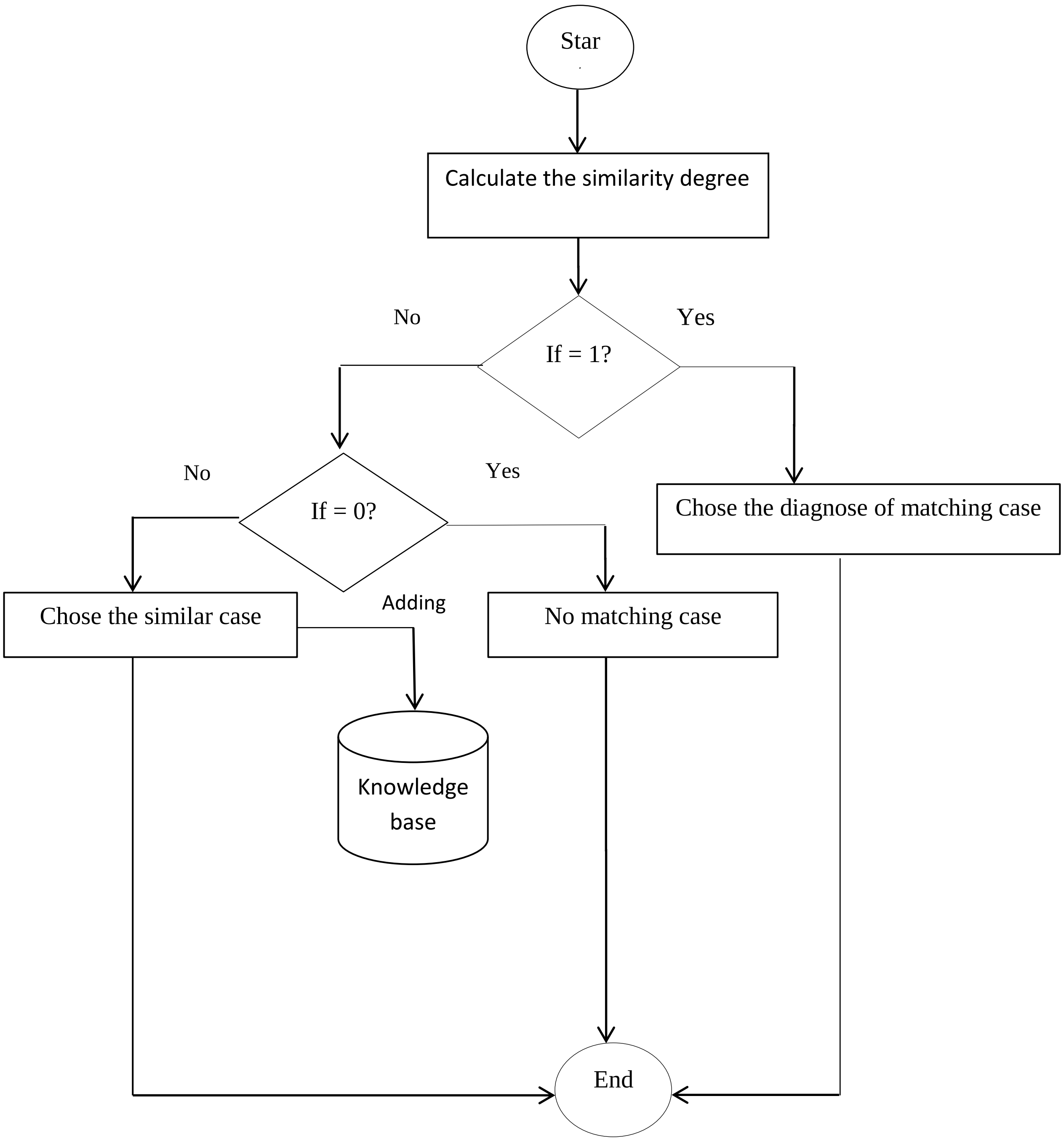

Figure 3.7: Retrieve process flowchart.

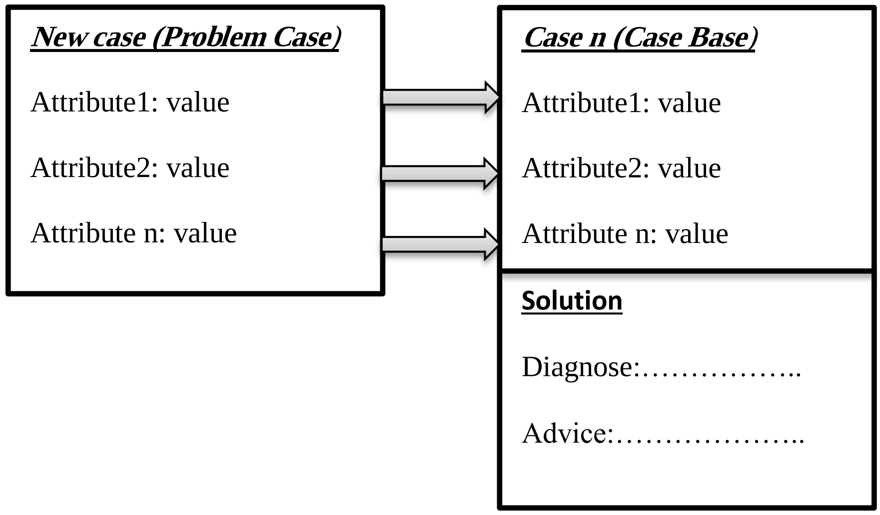

Figure 3.8: Similarity computing of cases attributes.

- **Reuse step**: Adapt the retrieved case to fit the new case. (If needed) to solve the problem. As in this example, two cases which have the same value or they share the same weak similarity. If this occurs, then the best solution for the current case has to be given by the experts in the domain.
- **Revise step**: Display the proposed solution to patient.
- **Retain step**: Adding the new problem with its solution to the case base. This eventually enables the system learns from its experiences.

3.3.3.5 User Interface Analysis

User interface is one of the most important components of the DSS because it is a way to interact between the user and the system [20]. At the same time, the user interface is a part of software that is used to convey information from and to user by using input and output of UI. This sub stage describes the mobile-UI based on the user's characteristics and conceptual of task, this leads to building a user interface which meets the common requirements among users. We have to bear in mind that when we design a user interface it be should be flexible and easy to use.

3.3.3.6 Hardware and Software Environment

The purpose of this stage is to identify software packages which are required for mobile-DSS development and the hardware that supports the software operations. When we choose the software, it should match the way we deal with knowledge base model and user interface model.

3.3.3.7 Usability Analysis

The usability analysis is verified if the DSS function is used easily and effectively. This leads to helping identify DSS requirements which could be used in the design stage. The usability can be measured by using some criteria such as a numerical value. This value is determined by negotiation between the user and DSS builder [20]. The next Table 3.7 illustrated how to estimate the usability of prototypes that are discussed and displayed in the sub stage of Support analysis. After collecting feedback and studying the values, the system builders add the necessary adjustments in prototypes to be ready for the design stage. Table 3.7 shows estimation of usability analysis.

Usability Operational	Description	Value
Learnability	Training and learning time for user to deal with system functions	%
Flexibility	Flexibility in using and dealing with system functions	%
Attitude	Users' opinions about the long term use	%

Table 3.7: Estimation of usability analysis.

3.3.4 Stage 4: DSS Design

The general definition of system design phase is the transformation of analysis models of the problem into design model [44] [61]. The DSS design involves modeling data [60], at this phase we can use a subtitle models and tools for representation:

1. Decision Modeling.
2. Knowledge Base Modeling.
3. User Interfaces Modeling.
4. System Structure

3.3.4.1 Decision Modeling

In this sub stage we will fully describe the decision process and present some possible scenarios related to all cases expected. The proper decision making process by end-user or the patient as he/she interacts with the system involves using ***sequence model***. Sequence model "is one of the UML models which basically shows interaction consisting of a set of objects and messages sent and received by those objects and demonstrate the behavior of objects"[59]. Figure 3.9 illustrates the concepts of sequence model.

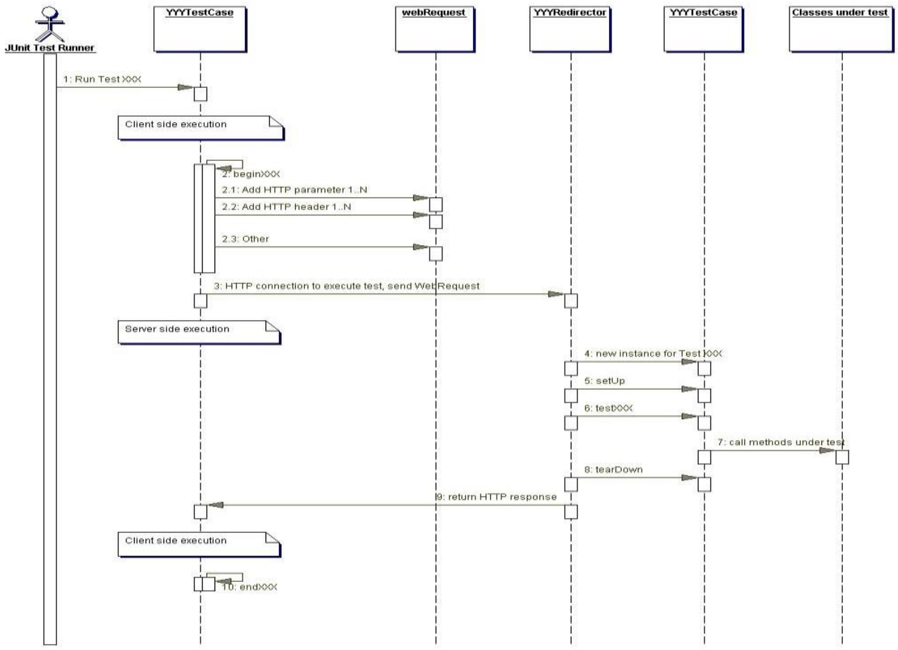

Figure 3.9: Sequence Model [59].

3.3.4.2 Knowledge Base Modeling

In KB modeling phase, we try to build Case-based diagnosis to retrieve past cases whose symptom lists are similar in nature to those of the problem case and suggest diagnoses based on the best matching retrieved cases. The following model shows the Case Base which represents the knowledge in our case study. Figure 3.10 gives a conceptual view model of case and Figure 3.11 shows a conceptual view model of case base.

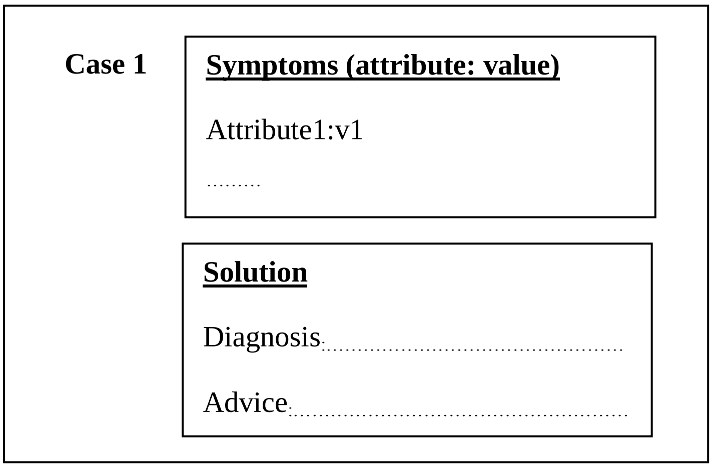

Figure 3.10: Conceptual view model of case.

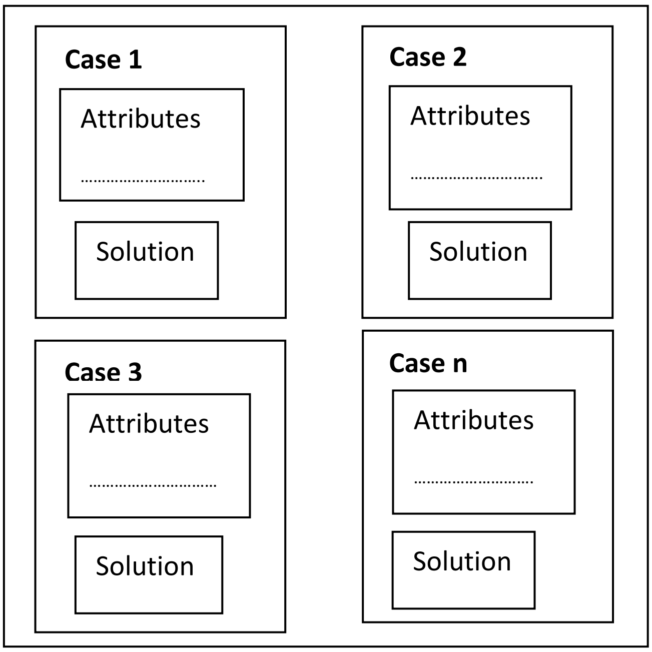

Figure 3.11: Conceptual view model of case base.

3.3.4.3 User Interface Modeling

In this sub stage, the prototypes are designed for building user interfaces based on user requirements and the nature of the system. The good way to create and generate quality interfaces is to design and test the prototypes using appropriate user interfaces tool.

3.3.4.4 System Structure

In this section, the general structure of the system is clarified. Actually, this structure represents the main components and the interaction between them.

3.3.5 Stage 5: User Evaluation and Adaptation

The evaluation process is a significant step for building any system. The evaluation outcome depends on the goals of the system. There are several evaluation methods, including interviews, questionnaires, observation, system logging, user diaries, laboratory experiments and field trials. For this research, we chose to use a questionnaire method to evaluate the prototype.

CHAPTER 4

Case Study

4.1 Introduction

This chapter presents a case study and it also includes the implementation stage of the proposed approach for building a prototype of mobile-DSS model for medical diagnosis. The case study is about the diagnosis of stomach diseases. The next sections describe all the steps, the procedures and the phases for building the prototype model.

4.2 Stage 1: Problem Domain

At this stage, the specific problem is defined and its scope is narrowed by the engineers or decision builders, and then uses a table which lists the identities or definitions of stakeholders. We should take the following points into consideration when we approach this stage:

4.2.1 Definition of the Problem

As we know that digestive diseases are very common and usually result into extremely concerning health issues in the long term. This means a quick and effective diagnosis is required to help the patient take certain important decisions. In case access to healthcare is unavailable or healthcare institutions are too far. From these reasons, we do believe that by using decision support system with mobile technology will help during the diagnosis process. We mainly aim at providing patients with proper and necessary diagnoses and also suggest therapies or medical advice anytime and anywhere. This stage also determines the problem domain which is in thesis is the medical domain for the proposed problem.

4.2.2 Definition of Stakeholders

This step identifies the stakeholders who interact with the system and their position by using Table 4.1.

Stakeholder_ ID	Stakeholder _ Name	Functionality
1	End-user	**Patient**: deals directly with the system and benefit from its services.
2	Expert	**Knowledge Expert**: helps in building diagnostic cases.
3	Administrator	**Programmer / Technical**: maintenance the system and dealing with mistakes

Table 4.1: Stakeholders' identification.

4.3 Stage 2: Analysis of Decision Task

At this stage the following steps are taken:

4.3.1 Definition of System Tasks

Identify the main tasks of the system and the tasks that related to decision processing. Figure 4.1 shows the use case model of the system tasks.

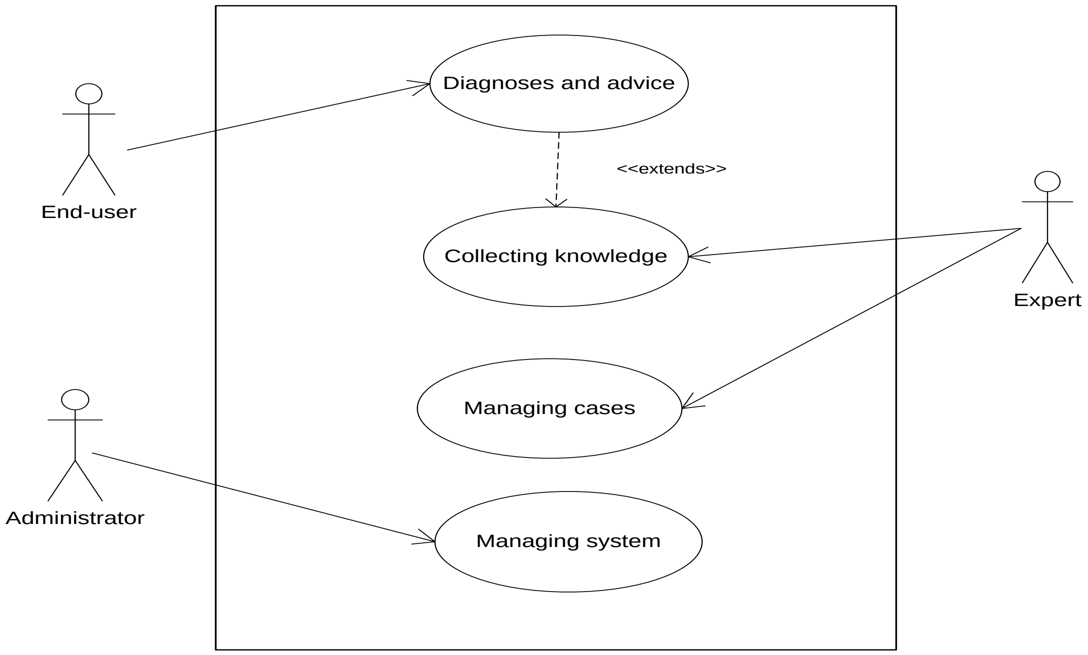

Figure 4.1: Use case model of system tasks.

According to the system tasks model, the decision process relies on ***Diagnoses and Advice Task*** which is in fact comes after ***Collecting knowledge task***. The main goal is to enable patients to make good decisions regarding their health condition. Therefore the system must provide reliable diagnoses, which are based on previous cases pre-stored in the knowledge base. We are using the following tables to clarify each task in the system in more details.

Task name/ use case name	Diagnoses and advice
Actor	End-user
Pre-condition	Collecting knowledge
Post-condition	Diagnose the cases and give medical advice
Short Description	In this task the patient enters the information into the system. The information is then used to generate advice based on the diagnosis given. This step depends on the task of collecting knowledge

Table 4.2: Diagnoses and advice task documentation.

Task name/ use case name	Collecting knowledge
Actor	Expert
Pre-condition	Available knowledge resources
Post-condition	Collecting knowledge from information resources
Short Description	In this task the expert collects the knowledge relevant to a specific domain from different resources.

Table 4.3: Collecting knowledge task documentation.

Task name/ use case name	Managing cases
Actor	Expert
Pre-condition	Expert enters the system correctly
Post-condition	Managing cases and modification
Short Description	In this task the expert manages cases in terms of adding, editing or removing cases.

Table 4.4: Managing cases task documentation.

Task name/ use case name	Managing system
Actor	Administrator
Pre-condition	Administrator enters the system correctly
Post-condition	Managing the system and problems
Short Description	This task involves handling the technical problems in the system and solving them.

Table 4.5: Managing system task documentation.

4.3.2 Knowledge Acquisition

In order to solve a decision problem in a particular domain, we have to collect knowledge about problem related to the domain and determine the process to be used in collecting this knowledge. Figure 4.2 illustrates the Knowledge acquisition process that used to collect knowledge.

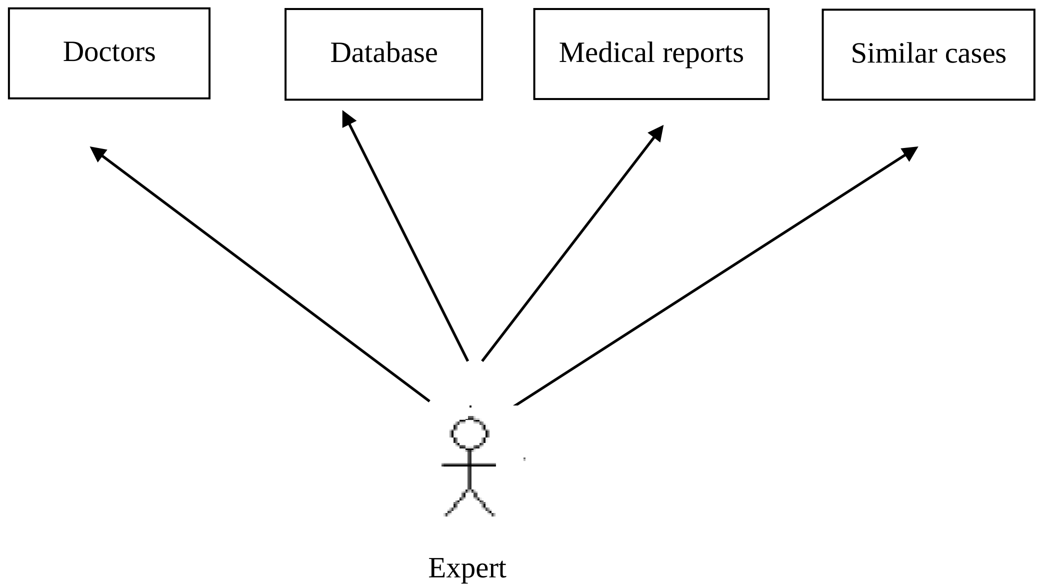

Figure 4.2: knowledge acquisition process.

4.4 Stage 3: Requirements Engineering

This stage includes:

1. User Analysis.
2. Support Analysis.
3. Decision Model Analysis.
4. Knowledge Base Analysis.
5. User Interface Analysis.
6. Hardware/ Software Environment.
7. Usability Analysis.

4.4.1 User Analysis

This step sheds light on end -user s' experience and knowledge. Actually at this sub stage, we will use special tables to assess users' knowledge and impression from this type of systems. There are two tables to illustrate this sub stage. Table 4.6: Knowledge estimation of end-user. Table 4.7: Knowledge estimation of expert and administrate.

User_ Name	Level of knowledge		Recommendation
<**User of system**: patient, visitor or any person benefits from the facilities of the system >	Experience with Mobile	sufficient	< Users should have enough experience when dealing with mobile technology >
	Experience with DSS type	none	
	Training in DSS	non	

Table 4.6: Knowledge estimation of end-user.

User Name	Level of knowledge		Recommendation
<**User of system**: expert or administrate>	Experience with Mobile	sufficient	<The expert or administrator should have sufficient knowledge about DSS and is to be trained prior to using mobile technology >
	Experience with DSS type	sufficient	
	Training in DSS	Trained	

Table 4.7: Knowledge estimation of expert and administrate.

4.4.2 Support Analysis

We use ***paper prototyping*** method at this sub stage, which basically consists of three prototypes. The first prototype represents the welcome screen which is the first encounter for users .This prototype presents a brief description on the disease as shown in Figure 4.3. The second prototype displays symptoms view on the screen as shown in Figure 4.4. Finally, based on the symptoms each user chooses, diagnosis and advice is given to the user or the patient as illustrated in Figure 4.5 Diagnoses and advice screen prototype.

Figure 4.3: Welcome screen prototype.

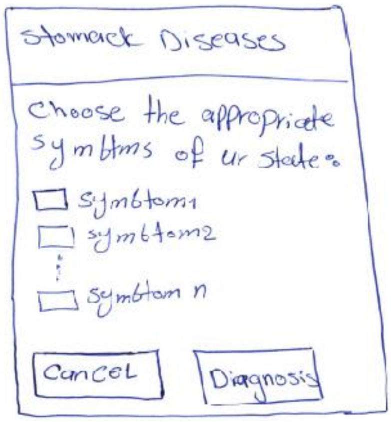

Figure 4.4: Symptoms screen prototype.

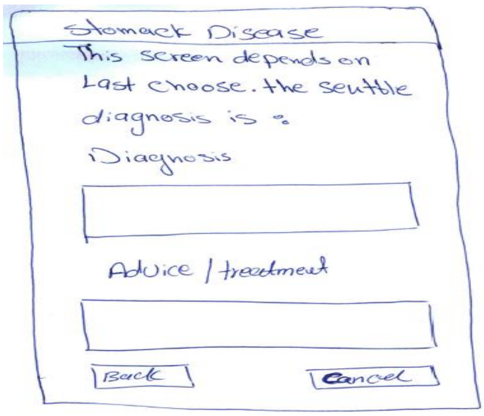

Figure 4.5: Diagnoses and advice screen prototype.

4.4.3 Decision Model Analysis

In the proposed system the decision task is the ***Diagnosis and advice task***. This task depends on using the knowledge base to make a required decision. See chapter 3 for more on the conceptual view and the main components of the whole process. The following Figure 4.6 shows the conceptual model of decision task.

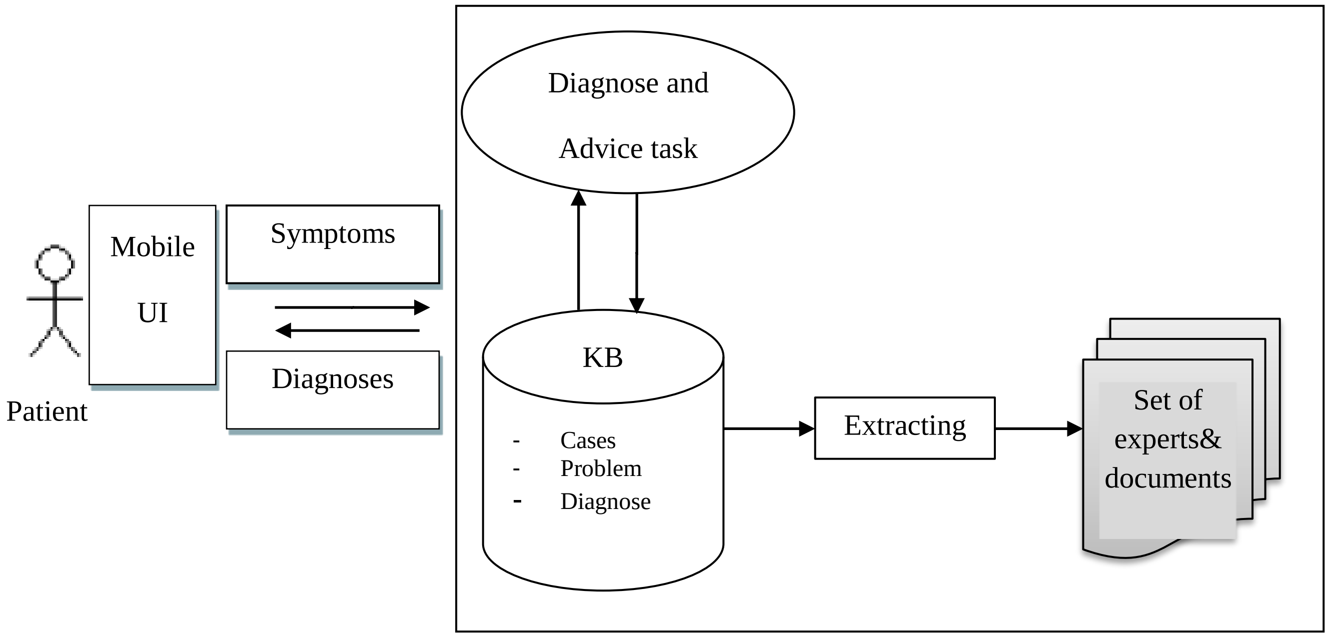

Figure 4.6: Conceptual model of decision task.

4.4.4 Knowledge Base Analysis

This stage involves a clear description of the steps taken for knowledge base building. These steps are as follows:

- **Knowledge Acquisition:** The required data/information for building knowledge base is collected through these methods.
    - Interviews with experts/ doctors specialized in stomach diseases, will use ***Brainstorming approach***, which involves two important steps [57]:
        - Collecting all relevant information from specialists of stomach illnesses. We do not only ask direct questions about stomach diseases, but we also open a discussion about all related details and issues.

- Filtering stage: This stage studies all the presented ideas and information. Experts decide which information is to be on the list of symptoms with corresponding diseases.

  - Obtaining information from previously checked cases which are stored as data in the database and medical reports.
  - Reviewing the similar/matching cases.

- **Knowledge Representation**: The first step in knowledge representation extracts or recovers past cases and experiences. (See Chapter 3 sub section 3.3.3.4). In our case study there are 8 attributes with level of importance each. We use the range for values (8 and 1) to evaluate the importance, where 8 is given for higher importance and 1 for lower importance. Table 4.8: Description of case attributes. There are five cases as shown Table 4.9: Description of cases.

Attribute no	Attribute name	Importance	value
1	Stomach pain	8	Yes/No
2	Stomach pain when eating	8	Yes/No
3	Stomach Pain when hungry	8	Yes/No
4	Nausea	6	Yes/No
5	Heartburn	6	Yes/No
6	Colic	8	Yes/No
7	Reflux food	8	Yes/No
8	Diarrhea	1	Yes/No

Table 4.8: Description of case attributes.

Attribute no	Case 1	Case 2	Case 3	Case 4	Case 5
	value	**value**	**value**	**value**	**value**
1	Yes	No	No	No	No
2	Yes	Yes	No	No	No
3	No	No	Yes	No	No
4	Yes	Yes	No	No	Yes
5	Yes	No	No	Yes	No
6	Yes	Yes	Yes	No	No
Diagnoses	Gastritis	Gastric ulcer	Duodenal ulcer	Hiatus hernia	Helicobacter infection
Advice	- Reduce the amount of food - Taking Aintiacid medications	- Taking Aintiacid medications - Consult a doctor	-Taking H.pyloric eradication therapy - Consult a doctor	- Avoid eating during night and sleep immediately after eating. -Consult a doctor	- Taking H.pyloric eradication therapy - Consult a doctor

Table 4.9: Description of cases.

- **Knowledge Extraction**: This step introduces the phases of ***CBR*** life cycle. This life cycle is used to search and retrieve the most resembling case in the knowledge base. The first step in ***CBR*** is:
    - **Retrieving step** :Similar case from case base by applying similarity metrics. Figure 4.7 shows the example of meager similarity computing of attributes. Having found the similarity of attributes, the general similarity between the current case and stored case are calculated as follow:

Similarity (C, S1) = 1/53*(0*8 + 0*8 +1*8 +1*6 + 1*6 + 0*8 + 1*8 +0*1) = 0.53

The comparativeness and similarity are applicable for each case entered the case base. Table 4.10 is used to register the values and at which the higher similarity is approved.

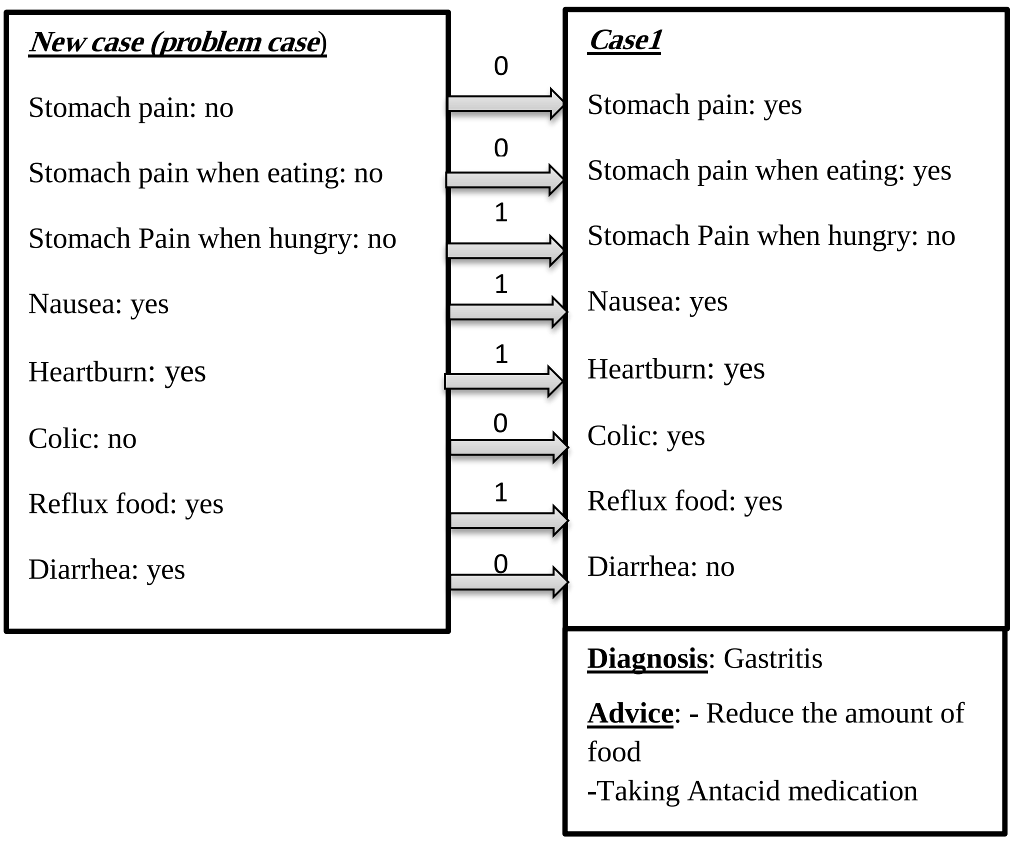

Figure 4.7: Similarity computing of cases attributes.

Similarity (c,s_n)	**Value**
Similarity (c,s_1)	0.53
Similarity (c,s_2)	0.42
Similarity (c,s_3)	0.30
Similarity (c,s_4)	0.87
Similarity (c,s_5)	0.72

Table 4.10: Similarity values.

The new retrieved cases are sent to the next step:

- **Reuse step**: If there are differences between the retrieved case and the current case.
- **Revise step**: provide the patient with the proposed solution.
- **Finally** comes the **Retain step** which consists of adding the new problem with its solution to the case base as shown in Figure 4.8.

Case *6*

Stomach pain: no
Stomach pain when eating: no
Stomach Pain when hungry: no
Nausea: yes
Heartburn: yes
Colic: no
Reflux food: yes
Diarrhea: yes

Diagnosis: Hiatus hernia

Advice: Avoid eating during night and sleep immediately after eating.

-Consult a doctor

Figure 4.8: New entry case.

4.4.5 User Interface Analysis

The concept behind building the prototype simply suggests that the patient enters the pathological symptoms and obtains diagnosis accordingly on their mobile phone user interface. The system will be implemented as a web site. This means that the communication between the user and system will be through setting up a web client and an application installed on mobile phones. It also requires a server that has the knowledge base. There must be a constant communication between the web client and server side to exchange the data through the ***GPRS*** technology and ***Wi-Fi*** connection. In this case study, the patient can use the facilities provided by the system such as entering the symptoms and receiving the results through the main UI. Experts can add, edit and delete items or data in the knowledge base through Expert mode.

4.4.6 Hardware and Software Environment

At this stage, we identify the software packages we need to construct the prototype of mobile-DSS development and the hardware that supports the software operations. This instant diagnosis application is designed to allow patients access the web site via their own mobile phones. In order to implement this proposal, we need software with these characteristics. In fact, we used the tools below because of their reusability and feasibility.

- Html.
- Php.
- Mysql.
- Java script.
- CSS.
- GPRS technology "is a new technology which allows users to make phone calls and exchange data. In fact, mobile phones equipped with GPRS can simultaneously make calls and receive e-mail messages".

However, the hardware requirements include access to Internet for any mobile device which must be equipped with browsing service

4.4.7 Usability Analysis

This sub-stage depends entirely on evaluating the prototypes that done in the support analysis step. Table 4.11 shows the usability analysis estimation. The values in Table 4.11 are intentionally left blank until the system is actually presented to users to add their opinions.

Usability Operational	Description	Value
Learnability	Training and learning time spent to deal with the functions of the system	-
Flexibility	Flexibility in using and dealing with system functions	-
Attitude	Users' opinions about the long term use	-

Table 4.11: Estimation of usability analysis.

4.5 DSS Design Phase

At the design stage, the following points should be taken into consideration:

1. Decision Modeling.
2. Knowledge Base Modeling.
3. User Interface Modeling.
4. System Architecture.

4.5.1 Decision Modeling

As we already explained in chapter 3 that we would use the sequence model to cover the decision process as shown in Figure 4.9. It merely depends on the interaction between the user and the system which produces the decision-making process. The sequence model includes two possible cases:

- ***The first case***: The patient enters the symptoms into the system. Then the system begins a searching process in knowledge base. It attempts to find either identical or similar case which could match the entered case. Based on the search results displayed, the patient can take his/her decisions.

- ***The second case***: The patient enters the symptoms into the system. Searching begins into the knowledge base and no identical or similar cases found. Figure 4.9: sequence model of decision process

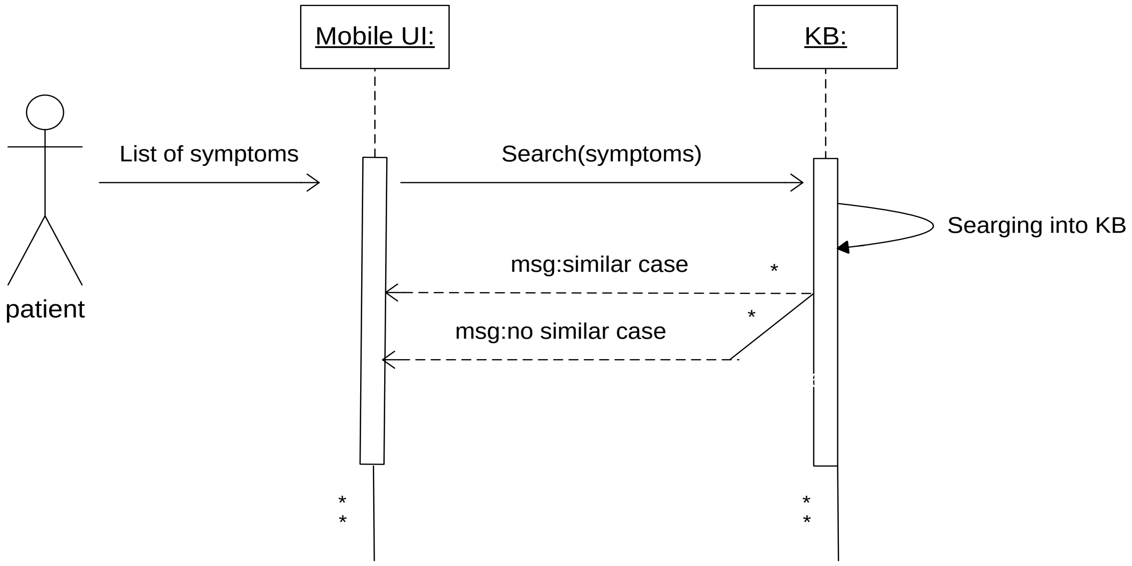

Figure 4.9: Sequence model of decision process.

4.5.2 Knowledge Base Modeling

The knowledge represents a set of cases which were previously stored into the knowledge base. The Figures below show some of the cases that are related to our case study.

Case 1

Symptoms (attribute: value)

Stomach pain: yes
Stomach pain when eating: yes
Stomach Pain when hungry: no
Nausea: yes
Heartburn: yes
Colic: yes
Reflux food: yes
Diarrhea: no

Diagnosis: Gastritis
Advice: -Reduce the amount of food
-Taking Anti-acid medications

Figure 4.10: Description of case 1.

Case 2

Symptoms (attribute: value)

Stomach pain: no
Stomach pain when eating: yes
Stomach Pain when hungry: no
Nausea: yes
Heartburn: no
Colic: yes
Reflux food: no
Diarrhea: no

Diagnosis: Gastritis ulcer
Advice: - Taking Anti-acid medications
-Consult a doctor

Figure 4.11: Description of case 2.

Case 3

Symptoms (attribute: value)

Stomach pain: no
Stomach pain when eating: no
Stomach Pain when hungry: yes
Nausea: no
Heartburn: no
Colic: yes
Reflux food: no
Diarrhea: no

Diagnosis: Duodenal ulcer
Advice: Taking H. Pyloric eradication therapy
- Consult a doctor

Figure 4.12: Description of case 3.

Case 4

Symptoms (attribute: value)

Stomach pain: no
Stomach pain when eating: no
Stomach Pain when hungry: no
Nausea: yes
Heartburn: yes
Colic: no
Reflux food: yes
Diarrhea: no

Diagnosis: Hiatus hernia
Advice: Avoid eating at night and sleep immediately after eating.
-Consult a doctor

Figure 4.13: Description of case 4.

Case 5

Symptoms (attribute: value)

Stomach pain: no
Stomach pain when eating: no
Stomach Pain when hungry: no
Nausea: yes
Heartburn: no
Colic: no
Reflux food: no
Diarrhea: no

Diagnosis: Helicobacter infection
Advice: Taking H.pyloric eradication therapy
- Consult a doctor

Figure 4.14: Description of case 5.

4.5.3 User Interface Modeling

This stage presents the designing of a mobile web user interface based on the requirements sought by users. Designers should take into account utilizing an appropriate technology in order to build a reliable interface. Figure 4.15 shows the main user interface and Figure 4.16 shows a healthy information user interface, Figure 4.17 illustrates symptoms user interface. Figure 4.18 is for the diagnosis user interface and Figure 4.19 expert user interfaces.

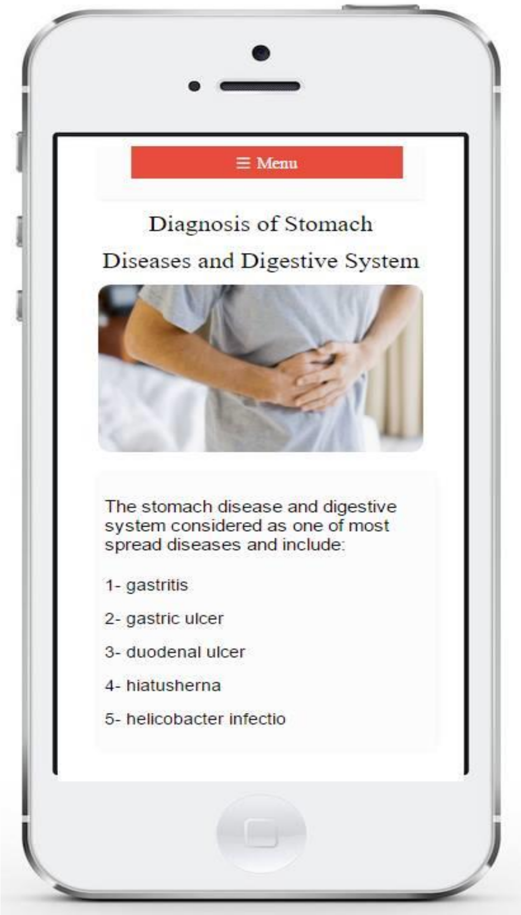

Figure 4.15: Main user interface.

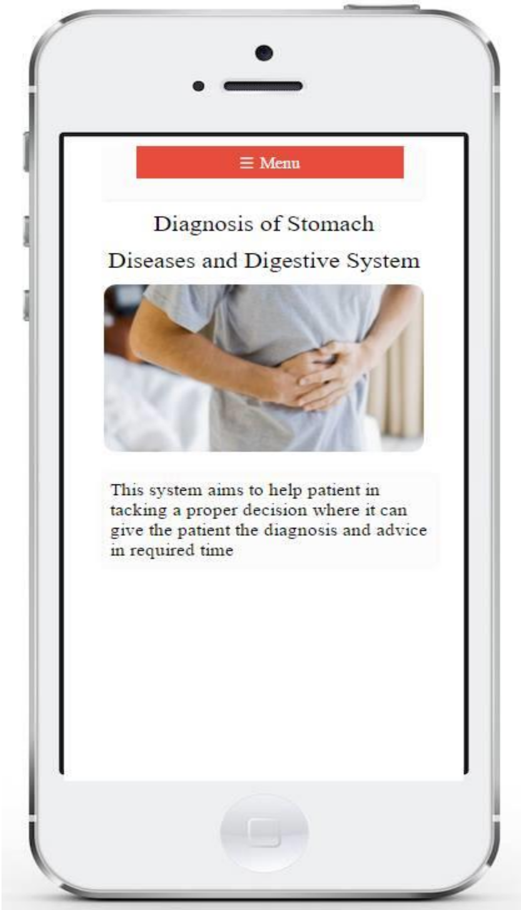

Figure: 4.16: Healthy information user interface.

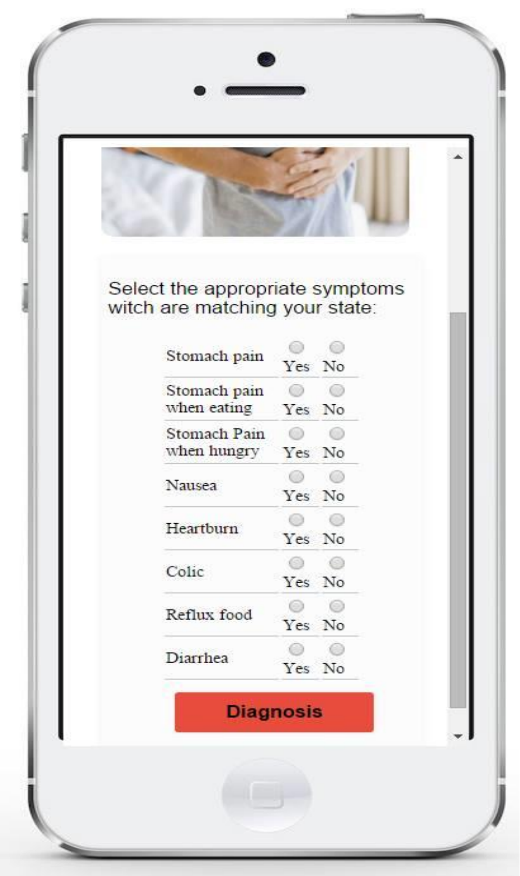

Figure 4.17: Symptoms user interface.

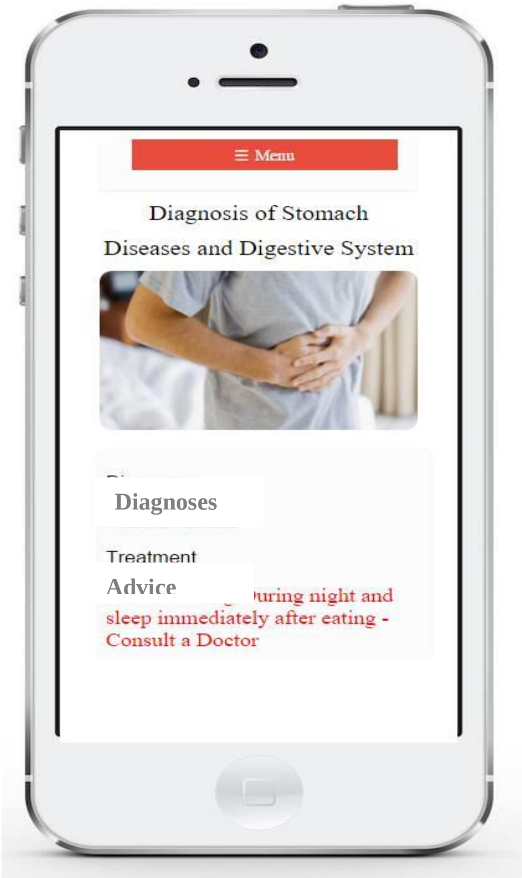

Figure 4.18: Diagnosis user interface.

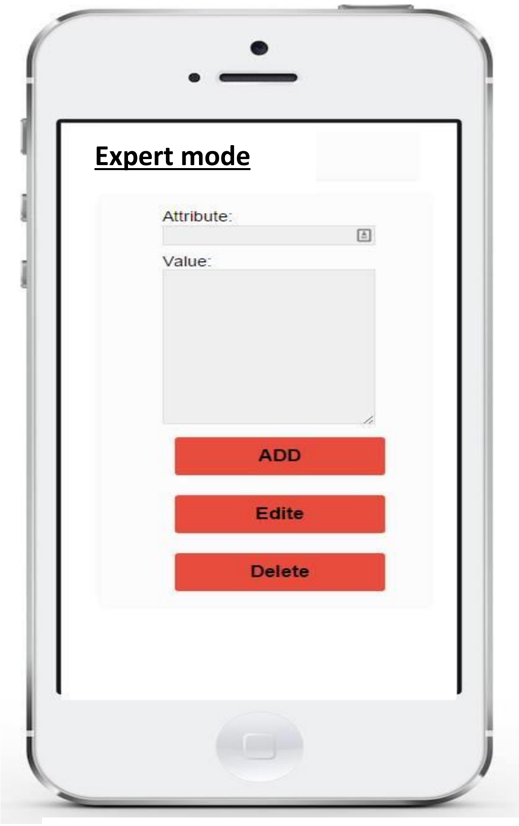

Figure 4.19: Expert user interface.

4.5.4 System Architecture

The general structure of the system consists of the main components and how they interact with each other. These main components include: knowledge base (**KB**), mobile user interface and wireless network. The knowledge base is designed to store specific knowledge which is required to obtain diagnosis and advice .In fact, mobile interfaces help users interact easily and smoothly with the system and exchange information. It is known that wireless networks are responsible for carrying data from users to server. In this research work, ***GPRS*** network and ***Wi-Fi*** connection will be used .Figure 4.20 illustrates conceptual model of system structure.

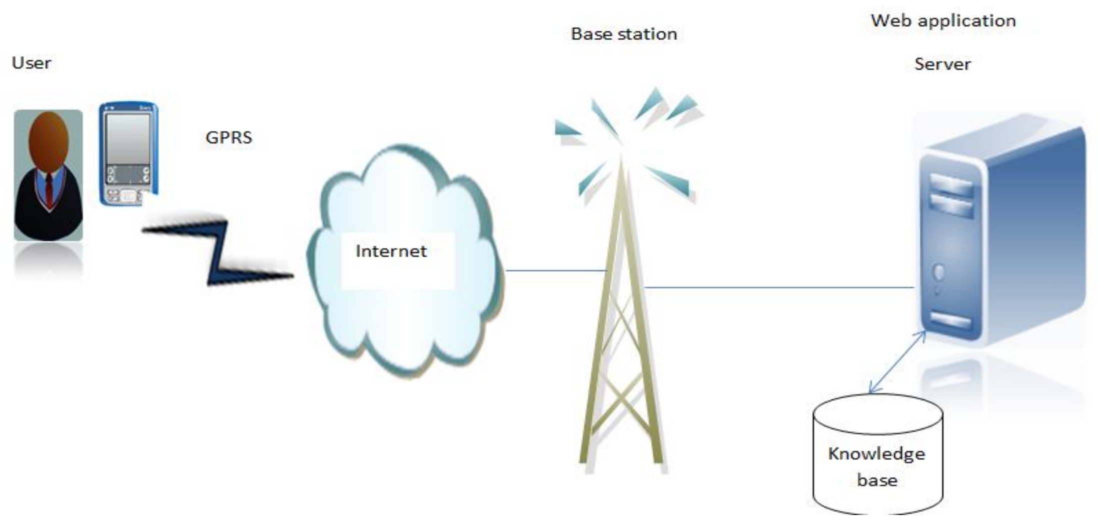

Figure 4.20: Conceptual model of system structure.

4.6 User Evaluation and Adaptation

During this stage the system prototype is evaluated by using the following questionnaire:

1. What is your opinion about the way the information presented?

- Clear
- Not clear

2. What is your opinion about the design of the user interface?

- Good
- Bad
- Needs some modification

3. In your opinion, does the system prototype provide reliable diagnosis and results?

- Yes
- To some extent
- not

4. Do you find the proposed system useful for patients?

- Yes
- No

CHAPTER 5

Conclusion and Future Work

5.1 Conclusion

In this dissertation, we presented guidelines for using mobile technology in decision support systems to conduct medical diagnosis. This approach guides developers and system builders to analyze and design mobile-DSS for medical purposes. The whole designing process relies on a number of important stages in the proposed approach.

The proposed work is divided into stages. Each stage contains a set of functions and models. The stages include the definition of the stated problem analysis of the prototype and the evaluation by end-users. Many reasons motivated us to use Decision Support Engineering (DSE) as a methodology with mobile computing. The main stages include the following:

- The chosen methodology has five phases: the ***problem domain***, ***decision task analysis***, ***requirements engineering***, ***system design***, and ***user evaluation*** and ***adaption***.
- Each phase has more sub stages. Each one has models and tools.
- Some of these models expressed by using flowchart and UML notations such as use case model and sequence diagram.
- ***In the first phase***, we clearly stated the problem domain and its nature. We also identified the beneficiary as shown in the table for defining stakeholders.
- ***In the second phase***, we described the tasks of the system and determine where the decision task analysis is and also the way that we used to collect the required knowledge to create a knowledge base. Brainstorming method was used through

data collection. The importance of this phase is to give a general view of system tasks and provided a description of each task. We utilized the Use case model for system tasks and the table to describe each task in the system.

- ***Requirement engineering,*** is considered as the third phase. It is one of the most important phases in building the prototype. At this stage, we analyzed and described the used methods and models for building: ***user analysis***, ***support analysis***, ***decision model analysis***, ***knowledge base analysis***, ***user interface analysis***, ***hardware and software environment*** and ***usability analysis***. User analysis**:** is finding more about users' experiences and knowledge of the suggested prototype by using knowledge analysis tables. Support analysis: means to know more about users' expectations of the facilities and services, the support prototype provides by using paper prototyping. Decision model analysis: intends to state the main components and interaction within the decision-making process. We described the decision scenario by using conceptual model for decision tasks**.** The knowledge base analysis: is an approach to describe the way is used to present the knowledge in the knowledge base. User interface analysis: has to be based on the user visualizing and requirements, therefore mobile web is used as UI. Hardware and software requirements: refer to software packages and the hardware required for building the mobile-DSS prototype. Usability analysis: helps estimate the prototypes that are shown in support analysis by using usability analysis via estimation table. This table depends on negotiation between the user and DSS builder.
- ***Design phase,*** is the fourth phase. The importance of this stage is the transformation of analysis models of the problem into design models. This stage also includes the use of subtitle models and tools to describe: ***Decision modeling, Knowledge base modeling, User interfaces modeling*** and ***System structure****.* In Decision modeling sub stage, the sequence model illustrates the decision process. Knowledge base modeling is the general view to present cases by using the conceptual view of case base. In user interface modeling the main interfaces are displayed. The general structure of the system is also presented at the final structure.

- ***User evaluation and adaptation***, is the final phase at which the proposed prototype was ready to be test and evaluated. In this phase, we used questionnaire as a tool to evaluate the performance of the user and the satisfaction among different users.

Finally, we presented a case study about stomach diseases to test how the proposed prototype functioned.

Throughout the implementation of the approach, we reached the following points:

- All the models and processes that were used in all the different phases worked very well and met all the requirements.
- The proposed approach stimulates the prototype of mobile-DSS to produce a proper and useful diagnosis and advice for patient especially in emergency cases by using mobile devices.
- The proposed models and processes of all stages help the system developers to build the required mobile-DSS.
- The proposed models and processes deal with the system inputs (symptoms) and process the outputs (advice) by using mobile web site with a high level of sufficiency.

5.2 Future Work

- The researcher intends to implement the proposed prototype (mobile-DSS) differently by including different types of disease. This is to create a useful and more effective system for more patients so they can receive proper check–ups and advice. Hopefully, this will help them make better decisions regarding their health condition and the healthcare they need.
- The prototype works very well. For future work, this prototype needs actual evaluation and implementation. This does not mean it is weak, but it’s only to increase its efficiency.

Reference

[1] G.Marin,” Decision support systems”, *Journal of Information Systems & Operation Management(Journal ISOM),* Vol 2,No 2,December 2008.

[2] M. Druzdzel and R. Flynn, “Decision support Systems “,In Encyclopedia of Library and Information Science, Vol. 67, pp 120-133, New York, 2000.

[3] Hans van der Heijden ,” Mobile decision support for in-store purchase decisions” , published in Science Direct ,Vol 42 (2) , pp 656–663, November 2006.

[4] H. Van der Heijden and L. S. Sørensen, "The mobile decision maker: mobile decision aids, task complexity, and decision effectiveness," Copenhagen Business School ,Working paper 2002.

[5] I.J. Pe´rez, F.J. Cabrerizo and E. Herrera-Viedma ,” *A Mobile Decision Support System for Dynamic Group Decision Making Problems*” IEEE Journals & Magazines, Vol 40 (6), pp 1244 – 1256, Nov. 2010.

[6] A. Isakow and H. Shi, “Review of J2ME and J2ME-based Mobile Applications”, International Journal of Computer Science and Network Security (IJCSNS), VOL.8 No.2, pp 189_198, February 2008.

[7] www.slideshare.net/nicole_wang/mobile-computing-introduction, Accessed in[19-March-2013].

[8] Deepak G , Dr. Pradeep B S ,” Challenging Issues and Limitations of Mobile Computing”, *International Journal of Computer Technology and Applications (IJCTA),* Vol 3 (1) pp 177-181, 2012.

[9] www.devhardware.com/c/a/Storage-Devices/Mobile-Computing-Technologies-an-Overview/ Accede in [20-March-2013].

[10]www.microstrategy.com/mobile/platform/The_Convergence_of_Mobile_Technology_and_Mobile_Intelligence.pdf. Acceded in [22/3/2013].

[11] A. S. Andreou, C. Chrysostomou, C. Leonidou, S. Mavromoustakos, A. Pitsillides, G. Samaras, C. Schizas, "MOBILE COMMERCE APPLICATIONS AND SERVICES: A DESIGN AND DEVELOPMENT APPROACH", 2003.

[12] www.linkedin.com/skills/skill/Mobile_Communications. Acceded in [20-March-2013].

[13] www.australianscience.com.au/technology/the-development-of-mobile-phones/ Accessed in [20-March-2013].

[14] B.Khatri, M. Singh and Dr. P. Chouskey,” Parallel Enhancement in M-learning and Mobile Computing”, *International Journal of Engineering Science and Innovative Technology (IJESIT)* Vol 2(1), January 2013.

[15] N. Gharaibeh , W. Bdour, S.M. Abu-Soud and I. Gharaibeh" Agile Development Methodologies : Are they suitable for developing Decision Support Systems", Applications of Digital Information and Web Technologies, ICADIWT '09. Second International Conference , pp 84 – 89, Aug. 2009.

[16] F. Zada, S. K.Guirguis, A. Sedky "Development of a Dynamic Model for Data-Driven DSS", *Journal of Emerging Trends in Computing and Information Sciences*, Vol. 3, No. 2, pp 255-261, February .2012.

[17] M. Nooraie , "Factors Influencing Strategic Decision-Making Processes", *International Journal of Academic Research in Business and Social Sciences*, Vol. 2, No. 7, pp 405-429, July .2012.

[18] A.Tariq and K.Rafi, "Intelligent Decision Support Systems- A Framework*", Information and knowledge Management*, Vol 2, No.6,pp 12-19, 2012.

[19] S. Malik and M. Shaikh," Enhanced Architecture of DSS with Embedded Data Sources", *Interdisciplinary journal Of Contemporary Research In Business(IJCRB),* Vol 1,No 3, pp 34-42. July .2009.

[20] K.B.C. Saxena,"Decision Support Engineering: A DSS Development Methodology" ,Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Science, vol 3 , pp 98 – 107 ,8-11 Jan 1991.

[21] Y.Wang and G. Ruhe, "The Cognitive Process of Decision Making", *Int'l Journal of Cognitive Informatics and Natural Intelligence*,Vol 1(2), pp 73-85, April-June 2007 .

[22] J. Fülöp, "Introduction to Decision Making Methods", Working Paper 05-6, Laboratory of Operations Research and Decision Systems, Computer and Automation Institute, Hungarian Academy of Sciences, Budapest, November. 2005.

[23] D. Williams and M.l. Kennedy, "Towards a Model of Decision-Making for Systems Requirements Engineering Process Management", International System Dynamics Conference, Bergen, Norway , August .2000.

[24]] J. Basilakis ,N. H. Lovell and S. J. Redmond, " Design of a Decision-Support Architecture for Management of Remotely Monitored Patients" Published in IEEE Transactions On Information Technology In Biomedicine, Vol. 14, No. 5, September. 2010 .

[25] Y. Anokwa, N. Ribeka, T. Parikh, Borriello. G. Borriello, and M. C. Were " Design of a Phone-Based Clinical Decision Support System for Resource-Limited Settings "published in ICTD '12 Proceedings of the Fifth International Conference on Information and Communication Technologies and Development ,pp 13-24 and ACM magazine in New York,2012.

[26] B. Chakravarti and Dr. S. B .Bhattacharyya ," Mobile Based Clinical Decision Support System", www.sbbhattacharyya.info/Mobile%20Based%20Clinical%20Decision%20Support%20System.pdf, Accessed in [14-March-2015].

[27] M.K. Lin, Mula. Joseph M, R. Gururajan, and J.W. Leis, "Development Of A Prototype Multi-Touch ECG Diagnostic Decision Support System Using Mobile Technology For Monitoring Cardiac Patients At A Distance", in Proc. PACIS, 2011.

[28] J. Nièsact, I. Colombet and et al," Determinants of success for computerized clinical decision support systems integrated in CPOE systems: A systematic review", published in AMIA Annu Symp Proc, pp 594–598,2006.

[29] M.S. Chalga and A.K Dixit, "Development of an ICT Based Support System for improving Health Care", *International Journal on Computer Science and Engineering*, Vol 3 No 5, pp 2183-2190, May.2011.

[30] D. DZEMYDIENEa and R.DZINDZALIETA, "Multi-Layered Architecture of Decision Support System for Monitoring of Dangerous Good Transportation", DB&Local Proceedings, CEUR Workshop Proceedings, Vol 924, pp 128-141, (2012).

[31]] D. Dolk, T. Anderson, and F. Busalacchi, "GINA: System Interoperability for Enabling Smart Mobile System Services in Network Decision Support Systems", presented at Hawaii 45th International Conference on System Sscience, 2012

[32] I.J. P´erez,S. Alonso,F.J.Cabrerizo and E.Herrera-Viedma," A Decision Support System Based on Mobile Internet", *Proceedings of the XIV Congreso Español sobre Tecnologías y Lógica Fuzzy (ESTYLF 2008), Cuencas Mineras (Mieres - Langreo), pp 241-247, September 2008* .

[33] Hans van der Heijden, Gabriele Kotsis and Reinhard Kronsteiner," Mobile recommendation systems for decision making 'on the go' ", International Conference on Mobile Business(ICMB), pp 137-143, July ,2005.

[34] R. Meredith, G. Shanks, D. R. Arnott and S. Carlsson," Mobile Decision Support for Triage in Emergency Departments", IFIP International Conference on Decision Support Systems, pp 714-723, Jul.2004.

[35] www.mobilecomputingproject.wordpress.com/2012/10/11/advantages-and-disadvantages-of-mobile-computing/. Accessed in [11- August -2015].

[36] M. Evers," Factors of Success and Failure for AccComputer-aided Instruments in Environmental Planning", Environmental Informatics and Industrial Ecology Lüneburg, pp 75-92, 2008.

[37] www.diuf.unifr.ch/ds/courses/dss2002/pdf/DSS.pdf Accessed in [8-March-2013].

[38] M. K. Ibrahem and S. Taha, "DECISION SUPPORT SYSTEM FOR NETWORK ROUTING OPTIMIZATION PROBLEM", Journal of Kufa for Mathematics and Compute, Vol.1, No.5, pp.52- 59 May, 2012.

[39] S. M. Stivaros, A. Gledson, G. Nenadic, X-J . Zeng, J Keane, and A. Jackson, "Decision support systems for clinical radiological practice", journal list :Br J Radiol. Nov; 83(995): 904–914, 2010.

[40] www.dssresources.com/dsstypes/kddss.html Accessed in [11-Augest -2015].

[41] Garbay, C. "Knowledge Acquisition and Representation." The Biomedical Engineering Handbook: Second Edition. Ed. Joseph D. Bronzino Boca Raton: CRC Press LLC, 2000.

[42] www.ai-cbr.org/classroom/cbr-review.html Accessed in [20-May -2015].

[43] A. Aamodt and E. Plaza, "Case-Based Reasoning: Foundational Issues Methodological Variations, and System Approaches", Vol. 7: 1, pp. 39-59, 1994.

[44] I. Watson," Case-based reasoning is a methodology not a technology", 17 March 1999.

[45] Julie Main, Tharam Dillon and Simon Shiu, " A Tutorial on Case-Based Reasoning", pp.1-28, 2001.

[46] Fatma Zada, Shawkat K.Guirguis, Ahmed Ahmed Hesham Sedky, "Development of a Dynamic Model for Data-Driven DSS", Pupfishes in Journal of Emerging Trends in Computing and Information Sciences", VOL. 3, NO. 2, February 2012.

[47] Ibrahim El Bitar, Fatima-Zahra and Ounsa Roudiès, " A Logic and Adaptive Approach for Efficient Diagnosis Systems using CBR", Publishing in International Journal of Computer Applications ,Vol 39– No.15, February 2012.

[48] Souad Guessoum, M.Tayeb Laskri, Hayet djellali and M. Tarek Khadir, "Combining Case and Rule Based Reasoning for the Diagnosis and Therapy of Chronic Obstructive Pulmonary Disease", Publishing in International Journal of Hybrid Information Technology, Vol. 5, No. 3, July, 2012.

[49] Mobyen Uddin Ahmed, Shahina Begum, Peter Funk, Ning Xiong and Bo Von Schéele, "Case-based Reasoning for Diagnosis of Stress using Enhanced Cosineand Fuzzy Similarity", Vol.1, No 1 Publishing ISSN 1864-9734, 2008.

[50] www.revisionworld.co.uk/gcse-revision/ict/system-life-cycle Acceded in [27 August- 2015].

[51] K.B.C. Saxena,"Decision Support Engineering: A DSS Development Methodology", Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Science,,vol 3 , pp 98 – 107 ,8-11 Jan 1991.

[52] P.Zarae and C.Rosenthal-Sabroux, "A COOPERATIVE APPROACH FOR INTELLIGENT DECISION SUPPORT SYSTEMS", Proceedings Of The Thirty-first Hawaii International Conference (HICSS) On System Sciences ,Volume5, pp 72-81, 1998.

[53] www.ubbcluj.ro/~per/Dss/Dss_3.pdf Acceded in [15- July- 2013].

[54] www. kandm.wikispaces.com/Knowledge+engineering Acceded in [26-June -2013].

[55] P. Tanwar, Dr. T. V. Prasad2 and et. al," Comparative Study of Three Declarative. "Knowledge Representation Techniques", International Journal on Computer Science and Engineering (IJCSE),Vol 02, No. 07, pp 2274-2281, 2010.

[56] www.upetd.up.ac.za/thesis/available/etd-03042004-105746/unrestricted/02Chapter2.pdf , Accessed in [16- May-2013].

[57] Tan, Choon-Keong and Baharuddin Aris, "ENHANCING AND ASSESSING STUDENT TEACHERS' CREATIVITY USING BRAINSTORMING ACTIVITIES AND ICT-BASED MORPHOLOGICAL ANALYSIS METHOD", ISSN-L: 2223-9553, ISSN: 2223-9944 SAVAP International, Vol. 2, No. 1, January 2012.

[58] S. Hameed, "Adoption of Decision Support Systems to Supplement Organizational Decision Making", *Life Science Journal*, Vol 9 ,No 2 ,June . 2012.

[59] www.agilemodeling.com/artifacts/useCaseDiagram.htm, Acceded in [14-auget-2015].

[60] S. Raghunathan, "A structured modeling based methodology to design decision support systems" Vol 17, Issue 4, Pages 299–312, 4 August 1996.

[61] www. ecomputernotes.com/mis/structure-and-classification/what-is-dss-what-is-the-purpose-of decision-support-system-in-mis, Acceded in [14-auget-2015].

[62]" Integrating Knowledge-Based and Case-Based Reasoning", Timur Chabuk, Mark Seifter, John Salasin, and James Reggia, August, 2006.

[63] Your .ORG and the Mobile Web: Strategies to Improve Your .ORG's Online Presence and Grow Visibility for Your Organization By Katrin Verclas, MobileActive.org A Whitepaper produced by MobileActive.org and .ORG, The Public Interest Registry, www.pir.org/pdf/Mobile_Web_Whitepaper2-20.pdf, Acceded in [23-Augest-2015].

[64] Mobile Web Developer's Gui Part I: Creating Simple Mobile Sites for Common Handsets, www.networksolutions.com/help/mobi-guide.pdf, Acceded in [23-Augest-2015].

[65]www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&uact=8&ved=0CC8QFjACahUKEwinlIzE6r7HAhUBtxQKHa_1BZc&url=http%3A%2F%2Fwww.cs.colorado.edu%2F~main%2Fsupplements%2Fchapt01.ppt&ei=bYrZVeepNYHuUq_rl7gJ&usg=AFQjCNG2n-htfs5QExifQ2ab9Tlk625BDw, Acceded in [23-Augest-2015].

[66] www2.engr.arizona.edu/~ece596c/lysecky/uploads/Main/Lec6.pdf, Acceded in [24-October-2015].