Sudan University of Science and Technology
College of Computer Science and Information Technology

Towards Context Aware Hospitals

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بسم الله الرحمن الرحيم

Sudan University of Science and Technology
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Towards Context Aware Hospitals

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الآيـــة

{وما توفيقي إلا بالله عليه توكلت وإليه أنيب}

صدق الله العظيم

سورة هود الآية (88)

الحمــد لله

للَّهُمَّ لك الحَمْدُ كُلُّهُ، وإلَيْك يَرْجِعُ الأمْرُ كُلُّهُ، عَلانِيَتُهُ وسِرُّهُ فَحَقُّكَ أنْتَ أنْ تُحْمَد، وحَقٌّ أنْتَ أنْ تُعْبَد، وأنْتَ على كُلِّ شَيْءٍ قَدِيْر

اللَّهُمَّ لك الحَمْدُ كالَّذِي تَقُولُ، وخَيْرًا مِمَّا نَقُولُ

اللَّهُمَّ لك الحَمْدُ بِجَمِيْعِ المَحَامِد كُلِّهَا

اللَّهُمَّ لك الحَمْدُ كَمَا حَمِدْتَ نَفْسَك في الْبُيُوْتِ والتَّوْرَاةِ والإِنْجِيْلِ والزَّبُورِ والفُرْقَان

اللَّهُمَّ لَكَ الحَمْدُ الثَّنَاءُ أجْمَلُهُ، ولك القَوْلُ أبْلَغُهُ، ولك العِلْمُ أحْكَمُهُ، ولك السُّلْطَانُ أقْوَمُهُ، ولك الجَلالُ أعْظَمُهُ

الجمدُ لله كثِيرًا طَيِّبًا مُبَارَكًا فِيهِ غَيرَ مكْفِيٍّ لاَ مُوَدَّع ولاَ مُسْتغنى عَنه رَبنا

الحمدُ لله الذِي لا يُرْجَى إلا فَضْلُه ، وَلا رَازِقَ غَيرُه

اللَّهُمَّ لك الحَمْدُ حَتَّى تَرْضَى، ولك الحَمْدُ إذَا رَضِيْتَ ، ولك الحَمْدُ بَعْدَ الرِّضَا

اللَّهُمَّ لك الحَمْدُ كَمَا يَنْبَغِي لِجَلالِ وجْهِك، وعَظِيْمِ سُلْطَانِك

اللَّهُمَّ لَكَ الحَمْدُ مِلْءَ السَّمَوَاتِ والأَرْض، ولك الحَمْدُ مِلْءَ الأَرْضِ، ولك الحَمْدُ مِلْءَ مَا بَيْنَهُمَا، ولك الحَمْدُ مِلْءَ مَا شِئْتَ مِنْ شَيْءٍ بَعْدُ

اللَّهُمَّ لك الحَمْدُ على ما أعْطَيْتَ ومامَنَعْت، وما قَبَضْتَ وما بَسَطْتَ

اللَّهُمَّ لَكَ الحَمْدُ كُلُّهُ أنْعَمْتَ بِهَا عَلَيْنَا في قَدِيْمٍ أوْ حَدِيْثٍ، أوْ خاصَّةٍ أوْ عَامَّةٍ أوْ سِرٍ أوْ عَلانِيَةٍ او حي او ميت او شاهد او غائب .

اللَّهُمَّ لك الحَمْدُ في السَّرَّاءِ والضَّرَّاءِ ولك الحمْدُ فِي البَأْسَاءِ والنَّعْمَاءِ ، ولك الحمْدُ في الشِّدَّةِ والرَّخَاءِ ، ولك الحَمْدُ على كُلِّ حَـال ولك الحَمْدُ بَعْدَ عِلْمِك، ولك الحمْدُ على عَفْوك بَعْدَ قُدْرتِك، ولك الحمْدُ على كُلِّ حَـال الحمْدُ لله في الأُوْلى والآخِرَة، الحَمْدُ لله الَّذِي لا يَنْسَى منْ ذَكرَهُ، والحَمْدُ لله الَّذِي لا يَخِيْبُ منْ دَعَاهُ، ولا يَقْطَعُ رَجَاءَ منْ رَجَاهُ

الحمْدُ لله عَلى كُلِّ شَيْءٍ، الحمْدُ لله مِلْء ما خَلَق، الحمْدُ لله عَدد ما فِي السَّمَواتِ وما فِي الأَرْضِ ، الحمْدُ لله عَدد ما أحْصَى كِتَابُهُ، الحمْدُ لله عَدد كُلِّ شَيْءٍ ، الحمْدُ لله مِلْءَ كُلِّ شَيْء

الحمدلله الذي وفقنا ويسر لنا كتابة هذا البحث..

DEDICATION

We dedicate this modest work to our

Fathers

Who did not donating us day by something and to

Mothers

Who have provided us with tenderness and love.

We tell them: You've to give us the gift of life and hope and nurture the passion for knowledge.

And to all our brothers, sisters, and our family.

To all our teachers,

Friends and colleagues

To candles that burn to light up for others

To everyone who teaches us a character.

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In the Name of Allah, the most merciful, the most compassionate praise Be to Allah, the lord of the worlds; the prayers and peace be upon Mohamed hid servant and messenger.

First, thanks to God who lights our ways and our minds. And then to the supervisor Mr. Aimen Abdel Aziz Hussein Ali who has guided us and direct us for the duration of the search.

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Abstract

This era (21 century) is characterized by revolution in communications and continues changes and improvement, so the companies with the participation of their products and marketing and the competition with other companies to gain access to a better lifestyle.

The health sector is one of the most sectors that could be affected and benefit from this progress. Patients who suffer from chronic diseases require care and monitor their status in a continuous way to deal with emergency situations that can occur to them. But in fact, care and treatment are limited to their presence inside the hospital only. Also inside the hospital, the patient moves between several units even up to a specialist doctor.

This research deals with four software modules essential, namely, (Electronic Health Record, the central system, the patient and the hospital) to monitor and follow up the case of patients who suffer from chronic diseases (diabetes specifically) and alert them in case of emergency and provide them with the necessary information to be followed in such cases and the nearest hospital can go. And contribute to the reduction of the measures taken by the hospital when the patient is greeted by the notification of his identity and his condition prior to his arrival to the hospital. Patient application, the application by receiving glucose readings and analysis and provide the appropriate service works for patient, in addition to the central system, and his job is the choice an appropriate closest hospital to the patient's current site and send patient information to the nearest hospital, which was selected as well as the information of the hospital to the patient.

المستخلص

يتسم هذا العصر (القرن 21) بثورة الإتصالات والتغييرات المستمره والتحسينات في التكنولوجيا، لذا تقوم الشركات بمشاركه منتجاتها وتسويقها و المنافسه بها مع الشركات الأخري للوصول لأسلوب حياة أفضل.

يعتبر قطاع الصحة من أكثر القطاعات التي يمكن أن تتأثر وتستفيد من هذا التقدم. المرضى الذين يعانون من أمراض مزمنة يتطلب رعايتهم و مراقبة وضعهم بطريقة مستمرة للتعامل مع الحالات الطارئة التي يمكن أن تحدث لهم. ولكن في الواقع تقتصر الرعاية والعلاج على وجودهم داخل المستشفى فقط. أيضا داخل المستشفى يتنقل المريض بين عدة وحدات حتى يصل إلى الطبيب المختص.

هذا البحث يتناول أربعة وحدات برمجية أساسية وهي (السجل الإلكتروني الطبي ، النظام المركزي ، المريض، و المستشفى) لرصد ومتابعة حالة المرضى الذين يعانون من الأمراض المزمنة (مرض السكري على وجه التحديد) وتنبيههم في حالة الطوارئ وتزويدهم بالمعلومات الضرورية الواجب إتباعها في مثل هذه الحالات، وأقرب مستشفى يمكن الذهاب إليه. والمساهمة في الحد من الإجراءات التي تقوم بها المستشفيات عند استقبال المريض عن طريق الإخطار عن هويته وحالته قبل وصوله إلى المستشفى. تطبيق المريض، يعمل التطبيق عن طريق إستقبال قراءات الجلوكوز وتحليلها وتقديم الخدمة المناسبة للمريض، بالإضافة إلى النظام المركزي و وظيفته هي إختيار المستشفى المناسب والأقرب لموقع المريض الحالي وإرسال معلومات المريض إلي المستشفي الأقرب الذي تم إختياره وكذلك إرسال معلومات هذه المستشفي إلي المريض.

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#	Term	Description
1	Jade	Java Agent Development.
2	JSP	Java Server Page.
3	HER	Electronic Health Record.
4	Glucose Guard	Patient's Android Mobile Application.
5	Central System	Make Control For The Whole System (Server).
6	NN	Patient's National Number.

Chapter One: Introduction

1.1 Introduction

The world is in a constant state of evolution with modern and advanced technologies, which play a very important role in all aspects and necessities of human life. Healthcare is one of the areas that are most affected by this evolution.

Hospitals need to improve their operations and deliver high-quality patient care with minimum cost. For this purpose, information like location and status of patients, medical equipment and medical personnel are required. This information is known as *context information*.

Context information must be captured in real time. In order to get context information, hospitals need to add monitoring activities both inside (doctors, medical equipment) and outside (patient's health condition, patient's location) their boundaries to identify emergency cases, take appropriate actions, and provide better services. One of the main advantages of context information is to reduce the amount of time needed before actual treatment starts.

1.2 Problem Statement

There are many problems that prevent hospitals to provide quick treatment to their patients. The following issues have been identified

- Context Information

  One of hospital main functions is to monitor patients' health conditions, provide required treatments, and follow up them. But when patients are outside hospital boundaries, hospitals will not be able to do so because of their lack of information about patients. On the other side, patients need information about hospitals that are available for him.

- Unnecessary procedures

  Upon patient arrival to the hospital, he has to go through a number of required lab diagnoses – which usually takes a considerable amount of time – before he is getting seen by a doctor, leading to the deterioration of his condition.

1.3 Research Question

How to enhance hospital emergency system using context-aware?

The quest to answer this question has led to various sub-questions which needed to be addressed. These are

1. How can hospitals get benefits of using context-aware concepts to improve their processes?
2. How could hospitals processes be adaptable to the context?
3. What are the other approaches and technologies needed to be involved in the proposed solution?

1.4 Research Objective

The objective of this research is to improve hospital emergency system by bringing a solution to the problems presented in Section 1.2, and answering the questions in previous section. The derived objectives are

- Context-aware

  The aim is to make hospitals aware about patients' health conditions, their locations and other information when they are outside hospital boundaries in order to provide better services. The second aim is to make a patient aware about the available hospitals to deal with.

- Avoid Non-Treatment Required Procedures

  The aim is to make hospitals more aware about their patients by providing them the required historical health records about patients requesting the service. Doing so helps hospitals in avoiding non-treatment procedures and focus only on treatment activities which leads to patient-oriented process.

1.5 Research Scope

The main area of this research is context-aware, one of ubiquitous computing fields, and how to get its advantages in healthcare sector. We decide to validate our approach on diabetes in particular.

1.6 Expected Contribution

The expected contributions of this thesis are

- Design a mobile application on patient-side that monitors him outside a hospital and determines his identity, health condition, and location. The mobile application will be used as a communication mechanism between the patient and other parties.
- Design a central system that retrieves patient's health records and specifies a list of alternatives of hospitals for patient and select the most appropriate one and then notify the patient about the selected hospital. Patient related information will be sent to the selected hospital.

1.7 Thesis Outlines

The rest of the thesis is structured as follows:

Chapter 2 presents background material about context-aware and hospital emergency systems and their terminology. In addition, previous methodologies of enhancing hospital emergency systems and their shortcomings are discussed.

Chapter 3 introduces our approach for enhancing of emergency process in hospitals by using context-aware. It shows the main components of the solution as well as the employed technologies.

Chapter 4 details the proposed approach and explains how it works, discusses its modules, functions and the relationships between them.

Chapter 5 validates our approach in action by taking a real case study. The validation results are discussed and compared to results obtained from other approaches.

Chapter 6 concludes the thesis by summarizing and discussing the contributions, with a discussion of future work.

Chapter Two: Literature Review

2.1 Introduction

For most of us, computing has been done during the last two decades on personal computer workstations and laptops. Interacting with computational artefacts and networked information has been largely a "desk experience." This is now changing in a big way. The core premise of context-aware computing is to create more usable technology which adapt to the user's context. In this research our aim is to apply this technology in healthcare in professional and efficient way, to produce more powerful and helpful services. (Coiera, 2004) Pointed out that there are some aspects such as context awareness will help health care professionals to shift part of their activities to machines. Therefore, health care will evolve as new technologies are adopted. Even if it is difficult to predict what the future hospital will be, Reinvention of health care is complex.

In this chapter we will present the previous concepts and definitions relating of context aware generally discussing Hospitals systems at the present time, and discus how context can effect in healthcare and patients especially, also will review some of previous research and studies related to this fields.

2.2 What is Context?

It's very important the understanding of context, cause its helps application designers for choose the right context to use in their applications. There are many definitions, (Schilit, et al., 1994) refer to context as location, identities of nearby people and objects, and changes to those objects. In a similar definition, (Brown, Peter J., John D. Bovey, and Xian Chen, 1997) define context as location, identities of the people around the user, the time of day, season, temperature, etc. Where (Ryan, Nick, Jason Pascoe, and David Morse, 1999) define context as the user's location, environment, identity and time. (Dey, Anind K, 1998) They enumerates context as the user's emotional state, focus of attention, location and orientation, date and time, objects, and people in the user's environment. Also (Abowd, Gregory D., et al. , 1999) define Context as any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves. And (Abowd, Gregory D., and Elizabeth D. Mynatt, 2000)

identified the five W's (Who, What, Where, When, Why) as the minimum information that is necessary to understand context.

2.2.1 Categories of Context

(Feng, Ling, Peter MG Apers, and Willem Jonker, 2004) Categorize context into two kinds, namely, user-*centric context* and *Environmental context*, as depicted in Figure1. They view Context as an n-dimensional space, constructed by n contextual attributes. Each dimension of the context is represented by one contextual attribute, describing one perspective of context.

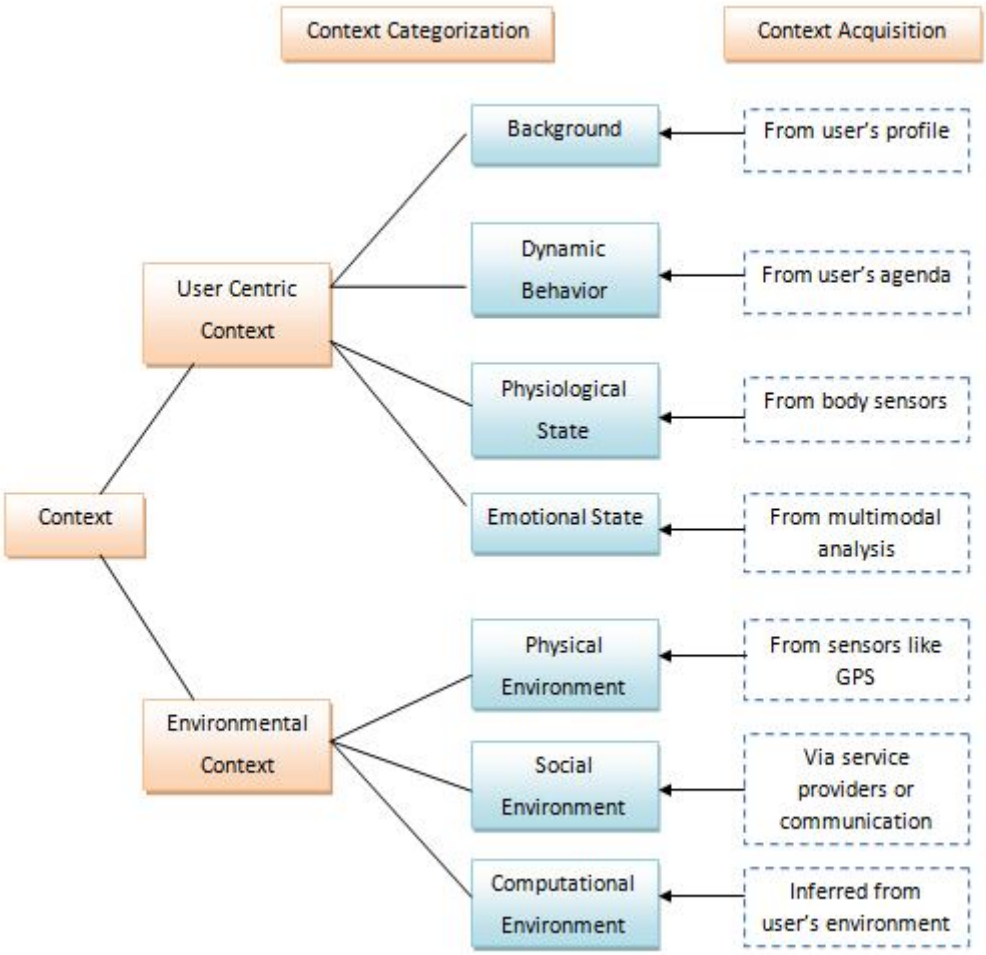


Figure 2.1: Context Categorization and Acquisition.

(Perera, Charith, et al., 2014) They divided the context into two categories primary and secondary.

Primary Context

Any information retrieved without using existing context and without performing any kind of sensor data fusion operations (e.g. GPS sensor readings as location in- formation).

Secondary Context

Any information that can be computed by using primary context. The secondary context can be computed by using sensor data fusion operations or data retrieval operations such as web service calls (e.g. identify the distance between two sensors by applying sensor data fusion operations on two raw GPS sensor values). Further, retrieved context such as phone numbers, addresses, email addresses, birthdays, and list of friends from a contact information provider based on a personal identity as the primary context can also be identified as secondary context.

(Van Bunningen, et al., 2005) Instead of categorising context, they classified the context categorisation schemes into two broader categories: operational and conceptual.

Operational Categorisation

Categorise context based on how they were acquired, modelled, and treated.

Conceptual Categorisation

Categorise context based on the meaning and conceptual relationships between the context. Applied their categories of context and context-aware features to the applications discussed in the related research they have presented. The results are in Table 2.1 below. Under the context type heading, they present Activity, Identity, Location, and Time. Under the context-aware heading, we present our 3 context-aware features, Presentation, automatic Execution, and Tagging.

From this table, we see that while many applications make use of both location and identity context, few make use of activity context. They also note that many applications use the presentation feature, but fewer use the execution and tagging features. Table 2.1 indicates that there are areas which need addressing in the space of context-aware applications.

2.3 Context Awareness

(Dey, Anind K, 2000) Have defined the term context-awareness if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task. Context awareness frameworks typically should support acquisition, representation, delivery, and reaction. In addition, there are three main approaches that we can follow to build context-aware applications. They applied their categories of context and context-aware features to the applications. The results are in Table 2.1 below, under the context type heading, they present Activity, Identity, Location, and Time. Under the context-aware heading, they present their 3 context-aware features, Presentation, automatic Execution, and Tagging.

System Name	System Description	Context Type				Context-Aware		
		A	I	L	T	P	E	T
Class room 2000	Capture of a class room lecture			X	X			X
Cyber guide	Tour guide		X	X		X		
Teleport	Teleporting	X	X	X			X	
Stick-e Document	Tour guide Paging and reminders	 X	X X	X	X	X X		X X
Reactive Room	Intelligent control of audio-visuals	X	X	X			X	
GUIDE	Tour guide			X		X		
Cyber Desk	Automatic integration of user services	X				X	X	
Conference Assistant	Conference capture and Tour guide	X	X	X	X	X		X
Responsive Office	Office environment control			X	X		X	
NETMAN	Network maintenance			X				
Field work	Field work data collection			X				X
Augment-able Reality	Virtual post-it notes		X	X	X			X
Context Toolkit	In/Out Board Capture of serendipitous meeting		X X	X X	X X	X	 X	 X
Active Badge	Call forwarding		X	X		X	X	

Table 2.1: Application of Context and Context-Aware Categories.

2.3.1 Characteristics of Context Awareness

(Van Bunningen, Arthur H., Ling Feng, and Peter MG Apers, 2005) Has identified comprehensively, and discussed, eight characteristics of context:

1. Is sensed though sensors or sensor networks.
2. Is sensed by small and constrained devices.
3. Originates from distributed sources.
4. Is continuously changing.
5. Comes from mobile objects.
6. Has a temporal character.
7. Has a spatial character.
8. Is imperfect and uncertain.

2.4 Context-Aware Computing

In the recent years, context-aware computing has extracted a lot of attentions from academic researchers and industrial practitioners. Context-aware systems usually makes of a large amount of sensed context information which is obtained from various physical sensors. (Moran, Thomas P., and Paul Dourish, 2009) Pointed that context computing is commonly understood by those working in ubiquitous/pervasive computing, where it is felt that context is key in their efforts to disperse and enmesh computation into our lives. They mentioned also that one important goal of context-aware computing is to acquire and utilize information about the context of a device to provide services that are appropriate to the particular people, place, time, events, etc. Also express that context information is useful only when it can be usefully interpreted, and it must be treated with sensitivity.

(Anind K. Dey, Daniel Salber, Gregory D. Abowd, 1999) They presented a list of defining characteristics for wearable computers. In each of these features, context plays an important role.

1. **Portable While Operational:** A wearable computer is capable of being used while the user is mobile. When a user is mobile, her context is much more dynamic. She is moving through new physical spaces, encountering new

objects and people. The services and information she requires will change based on these new entities.

2. **Hands-free use:** A wearable computer is intended to be operated with the minimal use of hands, relying on speech input or one-handed chording-keyboards and joysticks. Limiting the use of traditional input mechanisms (and somewhat limiting the use of explicit input) increases the need to obtain implicitly sensed contextual information.
3. **Sensors:** To enhance the explicit user input, a wearable computer should use sensors to collect information about the user's surrounding environment. Rhodes intended that the sensors be worn on the body, but the real goal is for the sensed information to be available to the wearable computer. This means that sensors can not only be on the body, but also be in the environment, as long as the wearable computer has a method for obtaining the sensed environmental information.
4. **Proactive:** A wearable computer should be acting on its user's behalf even when the user is not explicitly using it. This is the essence of context-aware computing: the computer analyses the user's context and makes task relevant information and services available to the user, interrupting the user when appropriate.
5. **Always on:** A wearable computer is always on. This is important for context-aware computing because the wearable computer should be continuously monitoring the user's situation or context so that it can adapt and respond appropriately. It is able to provide useful services to the user at any time. In the study conducted by **(Gu, Tao, Hung Keng Pung, and Da Qing Zhang, 2004)** Explain that merging pervasive computing solutions provide "anytime, anywhere computing by decoupling users from devices and viewing applications as entities that perform tasks on user's behalf.

Context-aware systems provide mechanisms for developing applications that are aware of their contexts and able to adapt to changing contexts seamlessly. A context-aware application uses an entity's context to modify its behaviour to best meet the user's needs in that context. Such applications can be used in various application

domains, Context aware computing aims to facilitate a smooth interaction between human and technology.

2.5 Hospitals System

Hospitals play a vital role in the health care system. With organized medical, nursing and other professional staff, they deliver diagnostic, treatment, convalescent and terminal care services 24 hours per day, 7 days per week.

Traditionally oriented on individual care, hospitals are increasingly forging closer links with other parts of the health sector and communities in an effort to optimize the use of resources. Many countries have some form of “gate-keeping” or referral system to control access to the relatively expensive services offered by hospitals. For such systems to work well, primary care services need to function effectively and be responsive to their local communities. Hospitals provide a broad range of patient-in and patient-out health care services to match the needs of the community.

Patient-In Services: Include medical, surgical, pediatric, and obstetric and rehabilitation services. Many hospitals also provide mental health services and services for older people.

Patient-Out Services: Most hospitals provide patient-out services including emergency services, day procedures, diagnostic and assessment services, and therapy services. Hospitals also support various community based programs to prevent or reduce the need for hospitalization.

The traditional health care, which provides for the patient's visit and diagnosis systems are costly and expensive, and due to the increasing number of diseases and patients have become not meet the requirements of these days, and the demand for pre-emptive techniques become increasingly for the prevention and detection of diseases, this tended health field for continuous care, mobile and everywhere. Through continuous monitoring and mobile is to know the status of patients at any time, any place and used to provide care for them. This special benefits patients with chronic diseases, the elderly and enriches them for repeated hospital visit. In this

permanent care system offers lower costs and facilitates patient care and rapid response and early disease.

2.5.1 Hospital Procedures

Hospitals procedures must be managed in a secure and efficient manner, to sure patients are served in an optimal way and easy and efficient manner by the hospital administration, so hospital management is keen to develop plans and strategies to achieve that. This increases the speed of completion of the operations and organization of time, thus achieving the desired efficient. In study of (Soemon Takakuwa ,Hiroko Shiozaki, 2004) Classified patients into nine categories, and each patient category the patients coming to the emergency department are classified roughly into ones transferred via ambulance, outpatients or ambulatory patients, and non-E.D. patients who need to take just medical examination. Furthermore, the patients are classified into three categories for outpatients and patients arriving via ambulance, that is, the first-, the second-, and the third degree symptoms, depending on seriousness of disease symptoms. In addition, outpatients are classified into ones on internal receptions.

After taking a series of required tests, the patient goes to the reception of the entrance and takes a seat to get the results of the tests. Finally, the patient moves to a consulting room to see the doctor in charge. Depending on the result of the diagnosis, the patient is to be hospitalized or leaves the hospital.

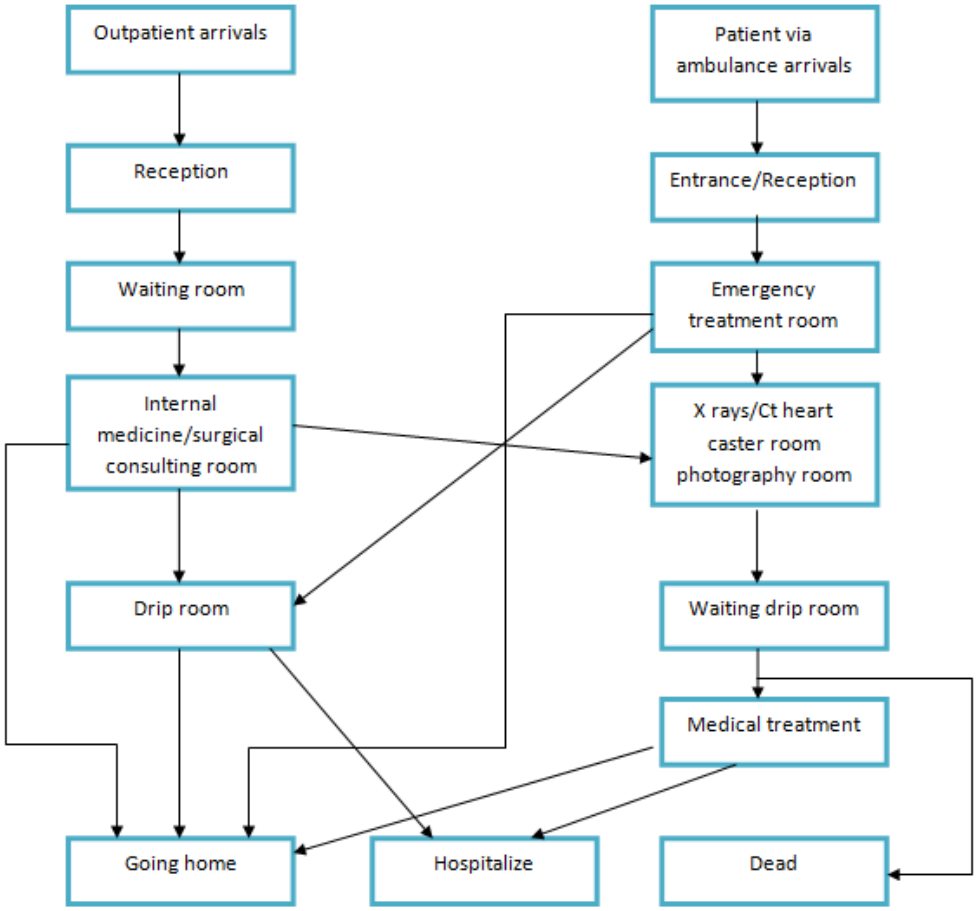


Figure 2.2: Outline of Patient Flows and Processes.

2.6 How Context Awareness Affect Hospital?

Many hospitals hope to develop and implement strategies to monitor patients even when the patient is out of the hospital. The challenge is particularly acute when the patient really needs to be observed 24 hours and that the proportion of critical condition. By adding the concept of (Context Awareness) on hospitals we can add a lot of features and benefits in the medical field by knowing information about the patient such as: location and condition and other information. Clinicians in modern hospitals are constantly moving around between different work settings, they are engaged in many parallel work activities, and they are constantly engaged in various cooperative problem solving groups.

(Jones, Lisa M., Kimberly J. Mitchell, and David Finkelhor, 2012)Explain that staff often require an awareness of the location—and other context—of their

colleagues, their patients, and flexible access to information like past and current patient records, medical references and drug databases. Rather than have to periodically check for information that might still be unavailable, they require a mechanism where they are notified of interesting occurrences when they occur, regardless of their present location. Hospitals are good candidates for the introduction of ubiquitous computing technology.

(J. Lapinsky, S. Weshler, M. Mehta, D. Varkul, T. Hallett, and T. Stewart, 2001) Pointed that one of the challenges of hospital work is the management of large amounts of information, including patient records, medical guides, and scientific papers used for evidence-based medicine. The information needs of hospital workers are highly dependent on contextual information such as location, role, time of day, and activity. For instance, the document more relevant to a nurse attending a patient might be that patient's chart, while for a physician might be the patient's health record. This has motivated the development of context-aware applications that adapt to changes in the environment to better assist hospital workers. (J. Hightower and G. Borriello, 2001) Pointed to that applications focus mostly on supporting intra-hospital communication and information access based on user location and role. In this regard, considerable work has been done in the development of robust approaches to location estimation for in-door working environments. Although, other contextual variables such as role and time of day can be easily determined, estimating the activity being performed is not an easy task.

2.7 Previous Studies

1. Authors in (Jesus Favela, Monica Tentori and Luis A. Castro, 2006) described an approach to estimate the activity being performed by hospital workers. The concept of context awareness generally serves widely in the medical field, and information management is one of the biggest challenges facing hospitals, which rely heavily on contextual elements such as location, role, time and activity. All these elements can be obtained relatively easily compared to the activity which constitutes some of the complexities in how to get it and use it to adapt to the setting of the hospitals. Most applications have focused heavily on the development of communication within the hospital, and access to information based on the patient's location and its role. Activity information could be relevant for a number of hospital

applications, such as deciding whom to call for help or facilitating access to relevant patient information. For instance, the vocera communication system uses a voice controlled badge to enable mobile users to communicate over the wireless network currently being used in some hospitals. They present an approach based in the use of neuronal networks to estimate hospital worker's activity. To train the network, they used the information recorded from a case study conducted in a hospital. By following this approach they could correctly estimate hospital workers' activities 75% of the time (on average). In addition, they discuss how once an application has strong evidence of the users' activity, it could adapt itself by displaying information relevant to the task at hand, and infer secondary context, such as availability. To illustrate this, they discuss how these results can be used in the design of two activity-aware applications. They plan to explore other estimation techniques such as the Hidden Markov Models to improve their results. Their hypothesis here is that by taking into account information of the past, they can determine the probability of switching from one state (the activity executed) to another (the activity to be estimated).

After we illustrate the highlight topics of this study above, we conducted some important points - that will help us in building our system - like *Service Availability* of this study was (inside the hospital) certainly in the activity information contextual element (this point had been discussion above), we will benefit from this point in our (patient-in) the hospital section by we will know the status of the hospital's staff (doctors, nurses, ...etc) like does this hospital's staff is busy or not, and if there is additional beds in this hospital , in general this will help us to manage the hospital's information.

2. Authors in (Favela J1, Rodríguez M, Preciado A, González VM, 2004) they extended a handheld-based mobile HIS (hospital information system) with ubiquitous computing technology and describe how public displays are integrated with handheld and the services offered by these devices. Public displays become aware of the presence of physicians and nurses in their vicinity and adapt to provide users with personalized, relevant information. An agent-based architecture allows the integration of proactive components that offer information relevant to the case at hand, either from medical guidelines or previous similar cases. Hospitals are

unpredictable information-rich environments that incorporate a huge specialized and computational framework ،the requirement for coordination and joint effort among specialists with various territories of ability, an intense information exchange ،and the mobility of hospital staff, patients, documents and equipment. This makes them perfect application situations for pervasive or ubiquitous computing technology. In this work, they explore the use of interactive public displays in hospitals. Public displays by themselves would offer only limited services, thus, they investigate their integration into a context-aware mobile computing infrastructure developed specifically for hospitals. Electronic patient records (EPR) integrate patient and clinician information so that approved the authorized medical personnel can retrieve important data to give sufficient treatment. A recent pattern in the development of these frameworks is the backing for mobile computing devices that can be utilized by the hospital staff to get to clinical records anyplace and at whatever time . One such framework is the CHIS (context-aware hospital information system), which gives access to data taking into account the user's context, and permits clients to send messages that will be conveyed in view of the recipients location and role, or the status of antiquities, for example, results of analysis. They have presented their efforts to extend a mobile HIS with interactive public displays as a direction toward the development of a pervasive hospital environment.

After we illustrate the highlight topics of this study above, we conducted some important points - that will help us in building our system - like *Service Availability* of this study was (inside the hospital) generally in all contextual elements (this point had been discussion above), we will benefit from this point in our (patient-in) the hospital section by we will notify the hospital's staff (doctors, nurses, ...etc) with patient's information like (laboratory result, status) when he/she inside the hospital, this information will send to the nearest staff and who have relation in treatment this patient, we will determine that by location contextual element, in general this will help us to manage the hospital's activity.

3. Authors in (Scott Mitchell, Mark D. Spiteri, John Bates, George Coulouris, 2000) described an application middleware that addresses the prerequisite for immediate high-quality multimedia communications in environments where users' work practices exhibit a large degree of physical mobility . A modern hospital is one

such environment, with assorted, regularly mission-basic, communication needs that are not tended to satisfactorily by existing frameworks . By integrating a multimedia framework with an event-based notification system, they are creating QoS DREAM (*Quality of Service for Dynamically Reconfigurable Adaptive Multimedia*), a platform that can give consistent, context-sensitive communications, which can adjust to clients' location and even follow them around. They described how they are using QoS DREAM to design what they term their concept of the "Intelligent Hospital". This is allowing them to determine a realistic set of communication and information access requirements within a busy hospital environment. The dissertation of this paper are that, (1) in a hospital there is a requirement for immediate high-quality multimedia communication sessions that do not require staff to know the present physical location of their colleagues. Furthermore, (2) staff often require an awareness of the location—and other context—of their colleagues، their patients, and flexible access to information like past and current patient records, medical references and drug databases. Rather than have to periodically check for information that might still be unavailable، they require a mechanism where they are notified of interesting occurrences when they occur, regardless of their present location. They proposed to replace existing intra-hospital communications with a system of digital audio and video streams coupled to an event-based programming mechanism for control and notification. The "Intelligent Hospital" will be wired with sensors to enable tracking the location of staff, patients and equipment. Terminals will deployed throughout the hospital providing access to audio/video conferencing and other information systems.

After we illustrate the highlight topics of this study above, we conducted some important points - that will help us in building our system - like *Service Availability* of this study was (inside the hospital) generally in all contextual elements (this point had been discussion above), we will benefit from this point in our (patient-in) the hospital section by the hospital's staff often require an awareness of the location—and other context—of their colleagues، their patients, and flexible access to information like past and current patient records, medical references and drug databases, this information will send to the staff by using their smart phones or tablets, in general this will help us to manage the hospital's activity.

4. Authors in (F Burstein, A Zaslavsky, N Arora, 2005) they applied agents to the highly dynamic and variable context of healthcare emergency decision-support domain. More specifically they advocate the use of mobile agents to support the deployment of an ambulance service in real-time. Mobile agent technology provides an attractive and important technique for building large-scale distributed applications in heterogeneous computing environments. A mobile agent can be viewed as an autonomous program that has the ability to transport itself between the nodes of a network entirely under its own control, carrying with it the data and execution state required to resume execution at the destination host from the point it ceased on the original host .Therefore, it is the agent that decides 'when to move', 'where to move', 'what to execute' and 'how to execute it'. They presented an implementation of the proposed agent based architecture, which was based on the specific functional and non-functional application requirements set out based on thorough analysis of literature. They also created an illustrative emergency scenario in order to demonstrate the validity and feasibility of their proposed model. From the evaluation of the implementation they were able to identify some of the major technical advantages it has to offer as well as challenges one needs to address in similar attempts. They choose mobile agents as the key enabling technology because they offer a single, general framework in which large-scale distributed real-time decision support applications can be implemented more efficiently. Healthcare was chosen as the target application domain to emphasize both the benefits derived from the exploitation of mobile agent paradigm in this domain as well as to demonstrate the benefits of the proposed approach in the highly uncertain context.

After we illustrate the highlight topics of this study above, we conducted some important points - that will help us in building our system - like *Service Availability* of this study was (outside the hospital) certainly in the location and time contextual elements (this point had been discussion above), we will benefit from this point in our (patient-out) the hospital section by we will determine the patient's location and choose the nearest hospital's location from the patient, so that will save patient time and make him/her reach at appropriate hospital in the right time.

5. Authors in (Patrick Lamber, Andrea Girardello, Francesco Ricci, Manfred Mitterer, 2009) illustrate the architecture of a mobile service, integrated in the hospital information system, aimed at supporting the user task in a day hospital scenario. The mobile device provides to the patient information messages related to her disease or her current task. Message delivery time is personalized using recommendation technologies that exploit contextual data such as the patient's position and current activity, and the history of user's previous message reading behaviour. MobyDay system is aimed at supporting the patient in a typical day hospital scenario of an oncology unit. Its main function is the personalization of the messages sent to the patients, and the support for filling user questionnaires (e.g., on quality of life). Messages sent to the patients can provide tips about how to improve the quality of life on certain circumstances, or simply instruct them about what to do next. This information flow is ultimately aimed at supporting the user task execution (analysis, treatment, and doctor's interviews) with the help of a mobile device (a mobile phone with Wi-Fi connectivity) used by the patients during the full day hospital process. The main functions of MobiDay are (1) Personalized instant messages. (2) Questionnaire and form filling. (3) Workflow support. (4)Identify the user-context with active RFID tags. (5) Web interface for the medical staff.

After we illustrate the highlight topics of this study above, we conducted some important points - that will help us in building our system - like *Service Availability* of this study was (inside the hospital) certainly in the location and activity contextual elements (this point had been discussion above), we will benefit from this point in our (patient-in) the hospital section by we will know the status of the hospital's staff (doctors, nurses, ...etc) like does this hospital's staff is busy or not, and if there is additional beds in this hospital , in general this will help us to manage the hospital's information.

6. Authors in (Bardram, 2004) they addressed the problems of clinical computer systems being unaware about their usage context, because some of the application for medical work in hospitals, which has appeared to be a strong case for applying context-aware computing, is independent on the context of use. Looking at clinical computer systems, including Electronic Patient Records (EPR), these systems often do not incorporate any notion of adaptation to the usage context. also clinicians are

continuously moved in a parallel way between different kinds of patients in a different sections in the hospital to do their work and they found the same user interface in different kinds of sections in the hospital, but the usage of medical and other information is highly dependent on the concrete usage situation – or in other words, is dependent on the context of use, This means that the clinicians need to manually adjust the user interface to fit the concrete usage setting and they waste their time to do this instead of do their main job, they are in this case through all the duration work, for this reason that mentioned above can solve it by making a unique user interface that reacts and adapts to their context for all different sections, this paper they present the design of a context-aware pill container and a context-aware hospital bed, both of which reacts and adapts according to what is happening in their context. The applications have been evaluated in a number of workshops with clinicians and patients. Based on this empirical work of designing, developing, and evaluating context-aware clinical applications, when we talk about application that serve the medical domain surely we must take in the regard all sides that can make it more comfortable, safety, easy to use and less wasting time. This paper based on evaluation of such applications they conclude that making clinical applications context-aware may be a key ingredient in creating more useful computer support for clinical work and hence enable computers in hospitals to move out of the offices and into the clinical work.

After we illustrate the highlight topics of this study above, we conducted some important points - that will help us in building our system - like *Service Availability* of this study was (inside the hospital) certainly in the activity contextual elements (this point had been discussion above), we will benefit from this point in our (patient-in) the hospital section by we will know the status of the hospital's staff (doctors, nurses, ...etc) like does this hospital's staff is busy or not, and if there is additional beds in this hospital , in general this will help us to manage the hospital's information.

7. Authors in (Miguel A. Muñoz, Marcela Rodríguez, Jesus Favela ,Ana I. Martinez-Garcia, Victor M. González, 2003) designed a context-aware mobile system that accounts for all contextual elements, allowing users to send messages and access hospital services when and where they choose. The system essentially

extends the instant messaging paradigm to add context-awareness as part of the message. Information management in a hospital setting requires critical collaboration, mobility, and data integration. The consideration of one patient can include numerous gadgets, besides, staff members often know each other only as "the doctor on the next shift" or the "nurse on duty," which means communication is often through roles, not specific identities . Adding to this many-sided urgency of the exchange communication is often intense and time critical, which requires a high level of coordination among both staff individuals and gadgets or other relics. At long last, staff individuals regularly depend on the gadgets themselves to transmit information, which presents logical variable. Correspondence systems must know where the gadget is, who needs it, when, and why . To put it plainly, managing hospital information is a challenge with unique requirements, and so far, no system has been able to address the complexity of the hospital environment. Reports are lost, guidelines are indistinct, and information is inadequate .For sure, numerous scientists recognize that hospital communication typically involves different locations, work hours, and communication paths. Mobile users are changing their context, prominently their location, however in a hospital; the context is much more than location . It is likewise the timing of the exchange; the location of a worker, device, or artefact; and the person's role‹ not just his identity. To understanding how their work gets done‹ they shape their technological design to directly address the contextual elements that characterize hospital information. They then identified characteristics that context-aware technologies should support in this environment. Finally, they built a system prototype and demonstrate it to hospital staff. The results of an evaluation session based on the Technology Acceptance Model (TAM) show that staff members find the system useful and easy to use and deploy it.

After we illustrate the highlight topics of this study above, we conducted some important points - that will help us in building our system - like *Service Availability* of this study was (inside/outside the hospital) certainly in all contextual elements (this point had been discussion above), we will benefit from this point in our (patient-in and patient-out) the hospital section by we will make communication between the patient and his/her doctors in a direct way by using messaging service that will be available in our application, this service will be available when the patient in and out

the hospital, in general this will help us to make continues communication between the patient and his/her doctors.

Table 2.2 contain some selected criteria that we are used to compare all these previous studies together from different side of view as we deducted them, and we dependant on some questions that illustrated below:

1. What is the **communication methods** used to implement each study?
2. What is the **performance** reached by each study when operating the system (low/medium/high)?
3. What is the level of **security** provided by each study, for keeping of the system (low/medium/high)?
4. What is the measure of **Technology Availability** provided by each study to cover most of the areas of Technologies (low/medium/high)?
5. What is the level of **Portability** provided by each study to apply its own system in different environments (low/medium/high)?
6. Did each study providing **integrity** factor compared to other systems (yes/no)?
7. What is the Level of Cost required by each study to add additional devices to work well (low/medium/high)?
8. What is level of **Service Availability** provided by each study (inside/outside)?
9. What is level of **Usability** provided by each study (easy/medium/hard)?
10. What is degree of the **Mobility** provided by each study to make its own system portable (low/medium/high)?

Study Number	Communication Method	Performance	Security	Technology Availability	Portability	Integrity	Cost	Service Availability	Usability	Mobility
1	PDA or tablet PC	High	High	High	Low	Yes	Medium	Inside	Easy	Medium
2	Mobile agent, handheld computer	High	Medium	High	Low	Yes	Medium	Inside	Easy	Medium
3	Mobile agent, flat-screen	High	High	High	Medium	Yes	High	Inside	Easy	High
4	Mobile Technology	Low	Low	High	Medium	Yes	Low	Outside	Medium	High
5	Mobile	Medium	Low	High	Low	Yes	Low	Inside	Easy	Low
6	RFID sensors, Computer screen	High	High	High	Low	No	Low	Inside	Easy	Medium
7	Mobile agent, handheld computer	High	Medium	Medium	Medium	Yes	High	Inside/Outside	Easy	High

Table 2.1: Illustrate the Comparison Criteria for the Previous Studies Above.

2.8 Summary

In this section we have to explain the concept of context aware and explained the hospital system currently and procedures generally followed in most hospitals, as we search for similar previous studies and compared with each other.

In the next chapter we will list the techniques that we use in the construction of the proposed system.

Chapter Three: Research Methodology

3.1 Introduction

This era (21 century) is characterized by revolution in communications and continues changes and improvement, to achieve better style of life a market share and competition between companies is leading this changes and improvement. In spite of the appearance of the new technologies and the variety and evolution, which have played a key role in society now, most areas did not benefit from these techniques as desired. One of the most important in these areas, which represents a very important element in the life medical field, information management in hospitals require a high effort, as well as the provision of medical services for patients requiring high accuracy to avoid the unexpected mistakes, and also how to deal with the cases in the hospital differs from the nature of the situation, dealing with cases regular and medium, of course, is different from dealing with dangerous cases. For example, diabetes is one of common and frequent disease and affects different groups of people, is considered diabetes syndrome is characterized by a disorder of metabolism and high anomaly in the concentration of blood sugar caused by lacks an adequate amount of the insulin hormone, or reduced tissue sensitivity to insulin, or both. Diabetes can lead to serious complications and may have possibly leads to premature death, so diabetics need immediate treatment when patient arrived at the hospital. The concept of context aware is one of the main concepts which contributed very effectively in all domain of life in spite of the recent appearance, the medical field is one of the areas that could benefit from this concept and apply it in different ways and get the desired results.

There is several research and previous studies have provided approaches in this regard. In this chapter, we will select the appropriate approach. The research objective of this chapter is to present a methodology that will be followed during the rest of the thesis based on the reviewed studies and technologies.

3.2 Aspects of Improvement

Several studies have been mentioned in Chapter 2 talked about the improvement of hospitals works in order to achieve a better patient recover and communication between hospital and patient so that to increase hospital efficiency, with using number of techniques and methods to reach that evolution. And those

studies have showed on how the hospitals can access to a state of awareness, whether that awareness was inside or outside hospital. Our system will cover some of the deficiencies found in the previous studies that we talked in Chapter 2, through continuous monitoring of diabetics out hospital and review his status until his arrival at hospital. Our system will cover outside hospital monitoring for diabetics. We will improve hospital work and increase time efficiency for patient by selecting the most suitable hospital for him\her. Also we provide hospital with necessary patient information that will increase hospital performance.

3.3 Ranges of Blood Sugar Levels

(D.abdullah, 2016) This section shows for us the ranges of Blood Sugar Levels that we obtained it from an interview with doctor Abdullah in his office, the ranges are shown below:

1. Ranges lower than (80) this means that the blood sugar level is low, and the patient must go to the nearest hospital.
2. Ranges from (81) to (200) this means that the blood sugar level is normal.
3. Ranges from (201) to (250) this means that the blood sugar level is high, but the patient can be an ambulance at home.
4. Ranges greater than (250) this means that the blood sugar level is high, and the patient must go to the nearest hospital.

3.4 Proposed Solution

Context aware hospital parts are: ***EHR database module, Central system module, patient module (android, simulation) and hospital module.*** Which has been develop to help patient with knowing the appropriate hospital and provide him\her convenient advices according to his/her condition that make the patient aware about his/her status.

One of hospital main functions is to monitor patients' health conditions and follow up them. Although when patients are outside hospital boundaries, hospitals will not be able to do so, because of their lack of information - (location, status) - about patients. On the other hand, patients need information about hospitals that are available for him/her (context information) and upon patient arrival to the hospital.

The proposed system aims to provide patient module (android) the ability to be context aware by modelling the environments in which patient in, and then monitoring the patient in a continuous way. Modelling and monitoring environments make patient module (android) aware with current patient needs. Patient module (android) must be also able to analyse his/her condition as well as provide better services (advices) according to the current patient status and that is the second aim of the proposed system. The proposed system aims also to skip the required-unnecessary procedures of hospital by receiving the analyst result from android. This ability optimises hospital work by reducing the time needed for analysis the patient condition.

The proposed system consists of the following modules:

- **EHR database module:** This unit is a large integrated system, and we are designed part of the database which we need to enable our system work in a good way.
- **Patient module:** This module divided into two parts:
    - **Android:** This part is responsible for analysis the reads that receive them from diabetes device and decide which action to take (just status message or connecting with central system to determine the suitable hospital).
    - **Simulation*:*** In this part we simulate the work of automatic diabetes device exactly, from time to time send the blood glucose level of the patient to android application to make an appropriate decision.
- **Central system module:** Receive the patient information (national number, location, status) from patient module (android) and select the appropriate hospital and send patient's information to the selected hospital.
- **Hospital module:** In this module every hospital that registered to our service previously have a page in our central system, this page provided to this hospital patient information such as (national number, location, status, case date, case time) this information came to hospital's page in form of notification.

3.4.1 System Scenario

The follow-up system diabetics continuously outside the hospital and by identifying the patient's condition based on the results that are obtained by measuring the diabetes device that sends readings automatically via Wi-Fi to the Glucose Guard directly in the case of automatic diabetes device or manually in the case of the manual devices. The Glucose Guard then analysis these readings to know the current status of the patient and make the right decision based on the result of analysis, There are three cases of diabetics, the first case, where the percentage of blood glucose level in the normal range (80-200) In this case, the system will not be doing anything but showing message tell him\her that he/she is in normal status. The second case, in which the blood percentage of blood glucose at a higher level of the normal range (between 201-250), and patient can be ambulance at home, then the system will send an alert message to the patient to take a piece of salt to compensate for the level of glucose in the blood. The third case, the range (greater than 250 OR lower than 80) then the Glucose Guard will get the current patient location via GPS located in the phone and send the patient's identity (national number) - every Sudanese citizen have a national number and when the patient want to use our service we ask him/her to type his/her national number and we verified it from our central system database which contain all Sudanese's National Number -, current position and patient's condition to the central system, then the central system analyzes the data received from the Glucose Guard to determines the most suitable hospital (ONE hospital) according to patient's appropriateness that are commensurate with the patient's location and the type of therapy that deals with the patient (insurance card or cash), and then the central system send hospital information such as (name, number, emergency number, and location) to the patient in his/her own application Glucose Guard. After that the central system sends patient information (national number, location, status, case date, and case time) to this hospital. In other case, in which the patient does not have the diabetes device and he\she feels Unmoral, the Glucose Guard contains an Emergency HELP service which will act as the same scenario of range (greater than 250 OR lower than 80) case.

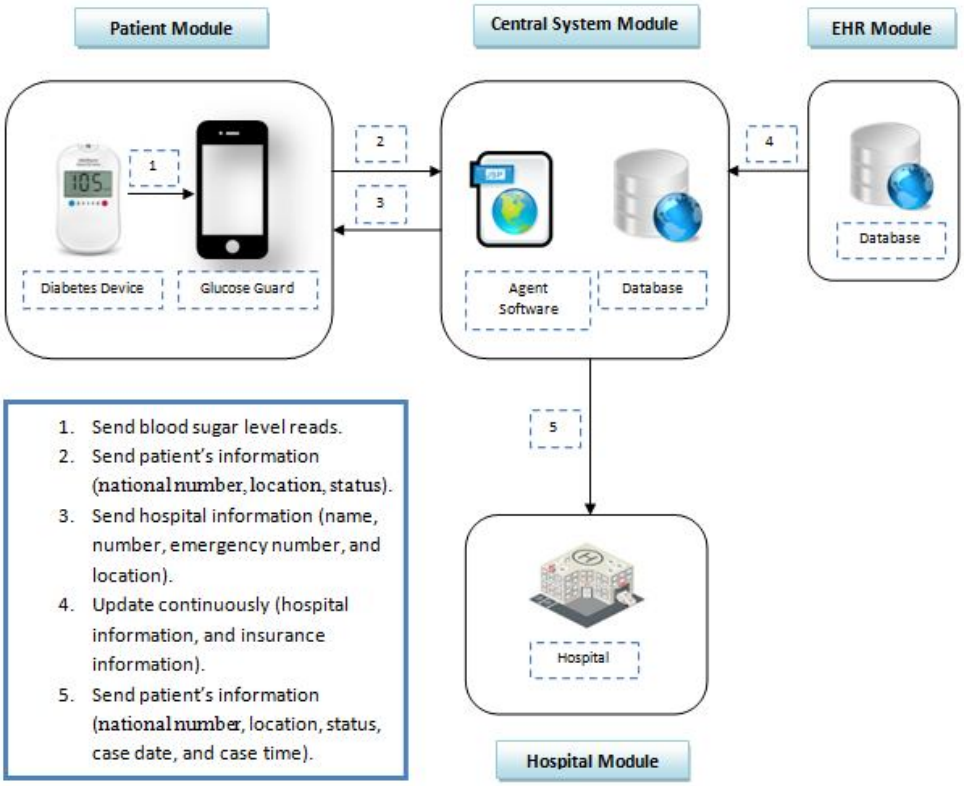


Figure 3.1: Illustrates the Context Aware Hospital Architecture.

3.5 System Features

In this system, we follow the patient out of the hospital. That means make the patient more aware of his/her condition most of the time and make him/her more knowing with the surrounding environment (hospitals location) and chosen the best for him/her, and guidance the patient to the right health decisions that fit the current health condition. In addition, we have added graphical user interfaces more user-friendly, the communication method that we used is the agent, which is a software programs that is take the appropriate decisions depending on the current situation based on the information that gave to the agent, further raising the performance of the system and the confidentiality of the system in general, we have the technical availability for a particular category of the operating systems that run on android environment, making the service availability medium, and the possibility of linking the system with other systems easy, all of these features and characteristics that we have added will lead society to context aware hospitals meet the needs of the patient at all times.

3.6 Diabetes Devices

(A new device to measure blood sugar without pains)Medical device gives approximate results for the concentration of glucose in the blood. It is considered a key element in the home to monitor blood glucose by people with diabetes or hypoglycaemia. There are several different ways to measure blood sugar at home, including the use of devices and diabetes that requires a small drop of blood obtained by pricking a finger or skin with a scalpel small pointy, then it is put blood taken drop on sensitive tape of the device, and insert the tape to a small device called a reader or the counter and read by the counter and gives the test result on the level of sugar in the blood, give a reading unit mg / dL or mmol / l, Figure3.2 (A) Illustrates the picture of the device. The method described above, useful for diabetics, which makes him aware of the amount of sugar at different times during the day, but the drawback of this method is the constant and painful twitching from time to time throughout the day for diabetics, which makes diabetics irregularly in this way. So the researchers try to find several kinds of different ways to cancel the concept of constant twitching and uncomfortable suffered by diabetics during most of the day, these methods differ in how to measure blood sugar, but all agree on one principle is to cancel the concept of acupuncture. For example, (Flore) device is a dedicated portable for patients with diabetes to measure blood glucose levels without the need for finger prick a needle to draw blood, as well as other characteristics of the measurement of vital activities in the body and encourage eating healthy foods and monitor the heartbeat and others. Device depends on the scan a finger instead of acupuncture is painful, where there is space dedicated to the reader of the finger, in which the patient puts his finger to wipe it and measure the level of glucose in the blood, and this reader uses a technology "Infrared spectroscopy", which monitors the level of sugar in the blood, Figure 3.2 (B) Illustrate the picture of the device. There is also a device called (Freestyle Liber), the device consists from sensing sugar measuring device without tingling prove to the skin and sugar measurement in the blood system reader, the device giving you the result as soon pass the scanner device on a slide show on the skin and replaced once every two weeks, this slide you sensing prove to the skin and are resistant to water As a reader it is reading and measurement of sugar when passed to the survey on perceived installed on the skin

and stores measurement results each time, and the device features reader lightness and the touch screen and memory to record the results of measurements for a period of 90 days to provide you with the numbers and graphs to monitor the concentration of sugar in the blood on a permanent basis, and can be linked to the internal memory of the device reader program a computer or an electronic application in order to be able to see the different measurements in the day or sent as reports and submit them to the physician, Figure3.2 (C) Illustrate the picture of the device. And many other devices, in spite of the many benefits that we can get from the scanner to measure diabetes household which reduce the occurrence of complications from high blood sugar and reduce the rate of severity over the long term, as well as a decrease in the short term, it can be life-threatening complications of hypoglycaemia in blood, but you cannot rely entirely on sugar measuring devices, domestic, should be reviewed specialist doctor from time to time to monitor developments.

(A) Prick Device (B) Flore Device (C) Freestyle Libre Device

Figure 3.2: Illustrates Some Sugar Measuring Devices.

3.7 Agent Software

(Software Agent) A software agent is a piece of software that functions as an agent for a user or another program, working autonomously and continuously in a particular environment. It is inhibited by other processes and agents, but is also able to learn from its experience in functioning in an environment over a long period of time. There are a number of different software agents, including:

- Buyer Agents or Shopping Bots: These agents revolve around retrieving network information related to good and services.

- User or Personal Agents: These agents perform a variety of tasks such as filling out forms, acting as opponents in games, assembling customized reports and checking email, among other tasks.
- Monitoring and Surveillance Agents: These agents observe and report on equipment.
- Data-Mining Agents: These agents find trends and patterns in many different sources and allow users to sort through the data to find the information they are seeking.

3.8 What are Electronic Health Records

(Michael & Thomas) Researchers have defined Electronic Health Records (EHRs) are computer systems that medical practices use instead of paper charts. All components of clinical practice are integrated into EHRs—from assessing a patient's chief complaint to developing a treatment plan. Everything that used to be handwritten by health care providers and staff is now entered into a computer, directly into the EHRs. EHRs are not only used to provide medical care, but also can manage all areas of a medical practice's daily operations. These electronic systems include scheduling features, multi-faceted calendars and appointment reminder systems, as well as functions for billing and submitting claims. Many practices already use electronic scheduling and billing systems, but EHRs can combine all of these functions – plus information from the clinical encounter – into one system that is useful for the entire practice staff.

3.8.1 Advantages of EHRs

(Nir & Taleah, 2011) Researchers have examined the benefits of EHRs by considering clinical, organizational, and societal outcomes. Clinical outcomes include improvements in the quality of care, a reduction in medical errors, and other improvements in patient-level measures that describe the appropriateness of care. Organizational outcomes, on the other hand, have included such items as financial and operational performance, as well as satisfaction among patients and clinicians who use EHRs. Lastly, societal outcomes include being better able to conduct research and achieving improved population health.

3.9 Development Tools

In this section, we will talk about the tools that we have used to develop this system. First we built an android application (Glucose Guard) to analyse and track the status of the patient outside the hospital using the android SDK. And we choose Android system because it is more readily available and commonly used systems and availability of source, and web application using Java (JSP), java is open source and free. That leaves its door open to variety of changes and modifications. Also we use (JADE) technique to enhance decision making, Expert communities regularly make changes such as building new frameworks to ease trouble for programmers, also there are numerous tools, IDE available for efficient coding in Java and there are also several thriving third party communities that provide excellent tools, adapters, and add-ons to enhance the performance of the developer. And finally, we linked these two systems by using a local LAN with IP address**.**

3.10 Summary

In this chapter we provided an introduction to the gaps faced by previous studies and the possibility of providing better services for patients with diabetes. And also we talked about the aspects of improvement covered by our system, benefitting from the care companionship outside the hospital. We explained in detail about the scenario that faces the patient in all cases and how our system shall respond to these cases. Also we explained the advantages of our system, and the mechanisms used, systems involved, measurement devices for diabetes and brief on diabetes disease.

The next chapter the aim of the research is to design a system analysis and full design for system.

Chapter Four: Analysis & Design

4.1 Introduction

The analysis phase is where the project lifecycle begins, also it is the part of the project where you identify the overall direction that the project will take through the creation of the project strategy documents. Gathering requirements is the main attraction of this phase. The design phase is important phase in project lifecycle, it show the overall picture of the system's requirements and operation's hierarchy.

4.2 Functional Requirements

- Every patient should have a National Number when he/her subscribe to the service.
- Measure patient's blood glucose level between different times and relatively close.
- Send readings to Glucose Guard via Wi-Fi.
- Analyses the coming reading, and takes appropriate action either show an alarm message or send emergency message to central system.
- Determine patient location via GPS in state of the emergency cases and send his/her location to central system to retrieve appropriate nearest hospital.
- Central system sends patient’s information to the appropriate nearest hospital.
- Central system sends hospital’s information to the patient to make him/her known appropriate nearest hospital.
- Provide guidance for the patient to take appropriate action in normal condition.

4.3 Non-Functional Requirements

- Human Factor
  - The UI in Glucose Guard must be user friendly.
- Reliability
  - Patient’s information (national number، location and status) must be trustworthy.

- Reading's analysis must be done accurately and according to certain criteria.
- The system shall to rectify patient is positioned in all cases is.
- The guidance of the patient must be carefully thought out and useful.

- Availability
  - Each diabetes patient could have the services when he/her reacts with the system (network availability).
- Performance
  - Cases management should be revision periodically, for example the adman's of the system must check the log of the system periodically (how many cases had been treated on day one, day two, and so on).
  - Patient should receive hospital information expresses on time, in case of (network disrupt) the central system should send to the patient an information message explain to him/her what's going on.

4.4 System Analysis

This section represents proposed system analysis including use case diagram, activity diagram, and deployment diagram.

4.4.1 Use Case Diagrams

Use case diagram describes functions and actors.

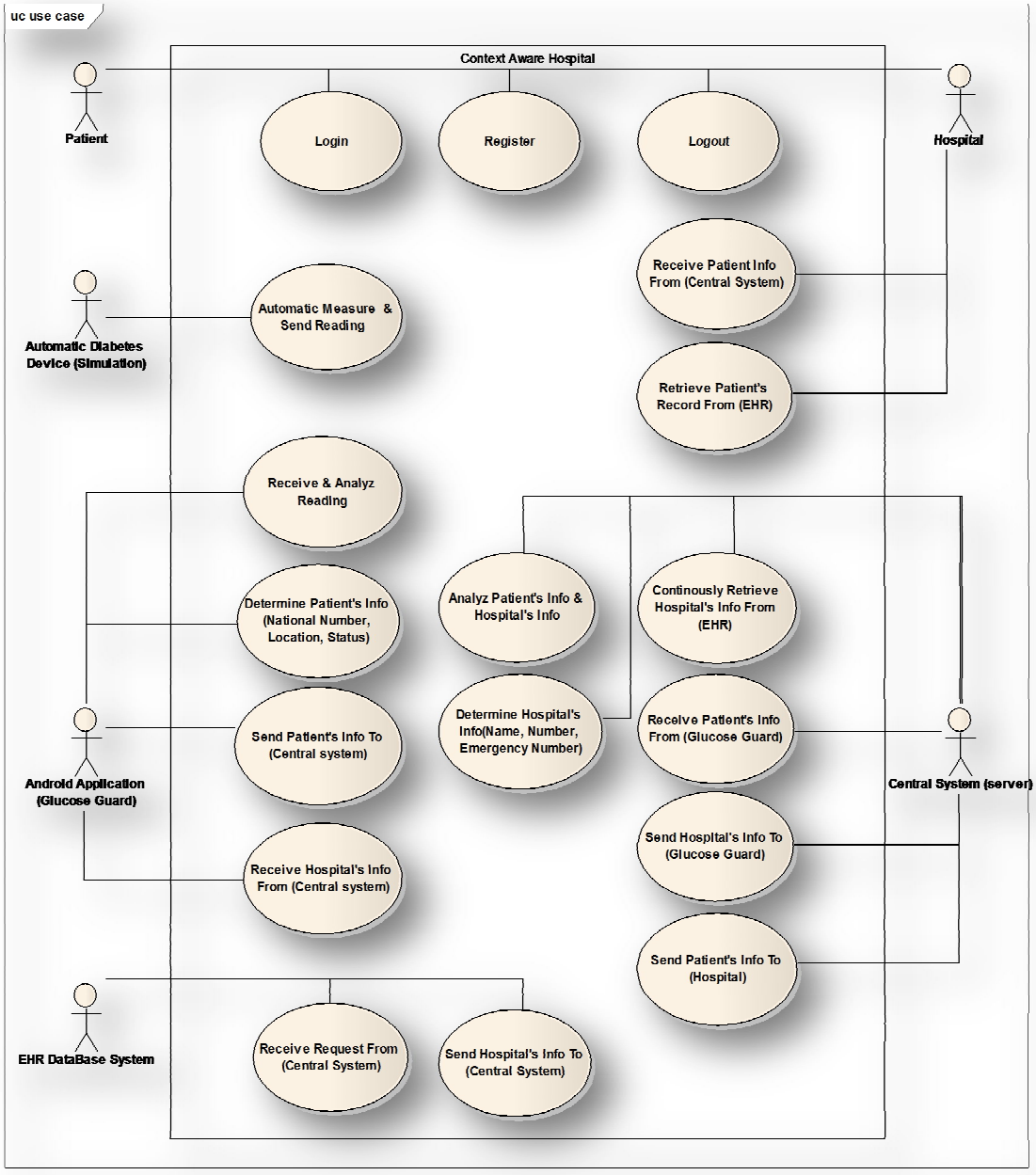


Figure 4.1: Use Case Diagram of System's Operations.

4.4.2 Sequence Diagrams

Sequence diagram describes the sequences of the system.

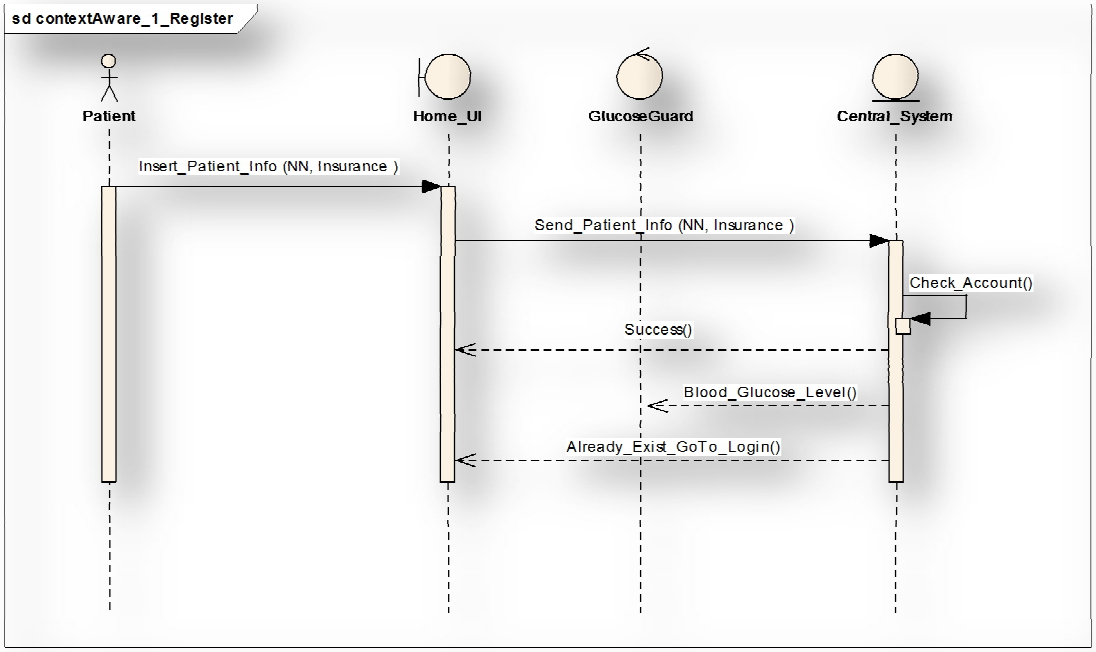


Figure 4.2: Sequence Diagram for register use case.

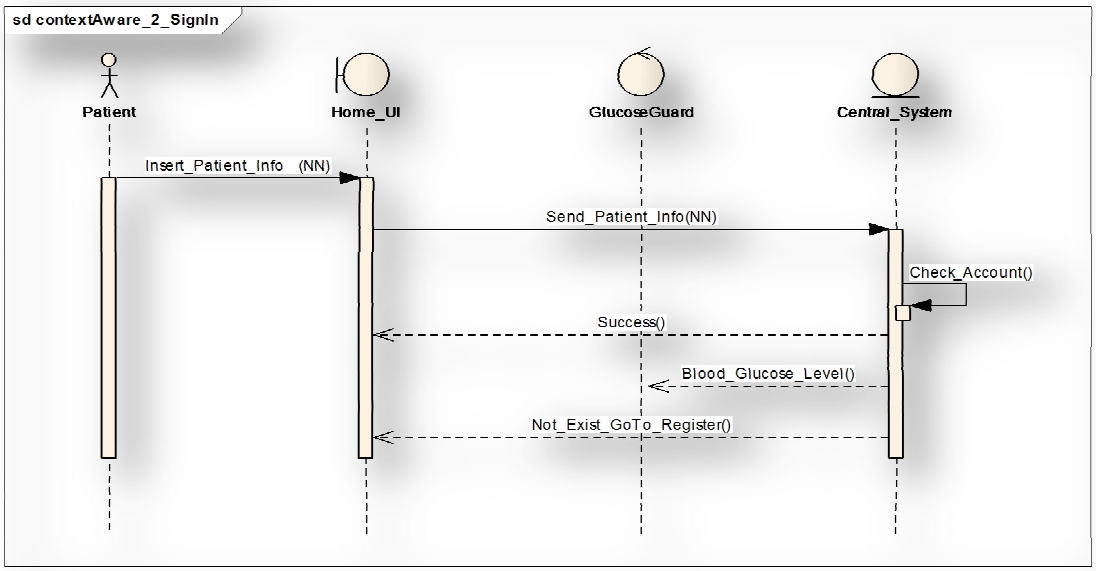


Figure 4.3: Sequence Diagram for sign in use case.

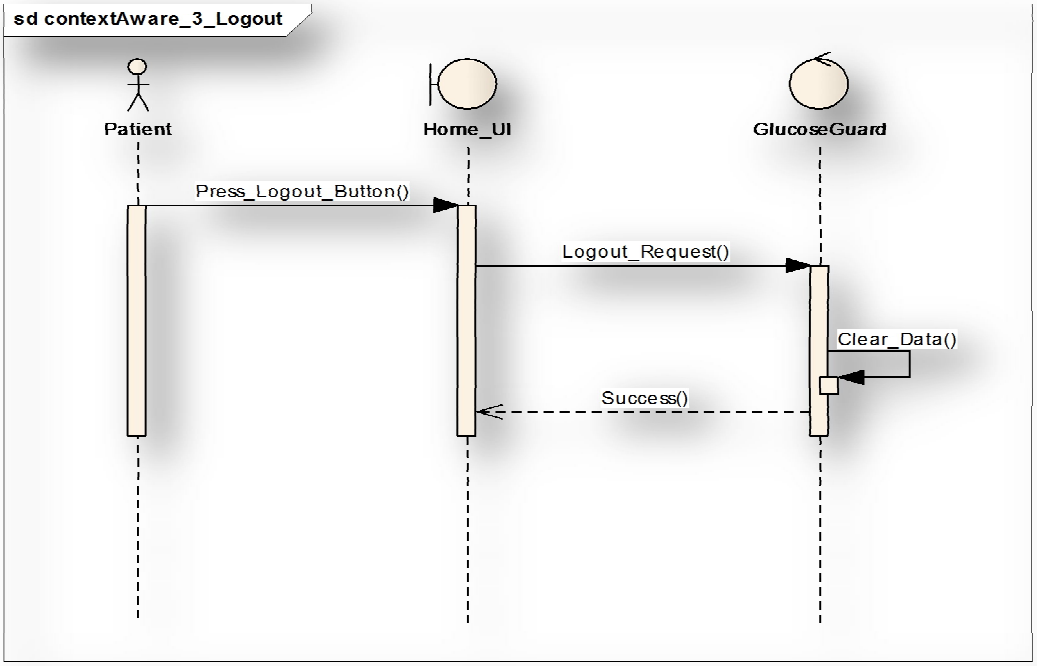


Figure 4.4: Sequence Diagram for log out use case.

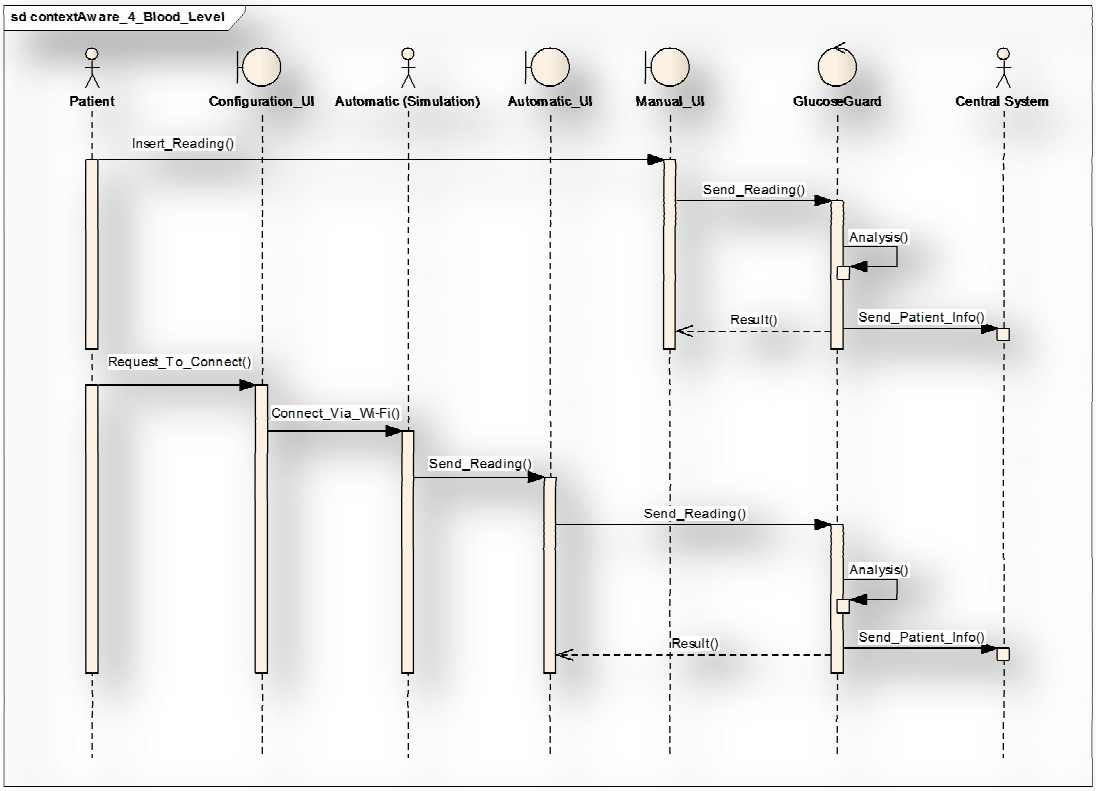


Figure 4.5: Sequence Diagram for Receive & Analyze Reading use case.

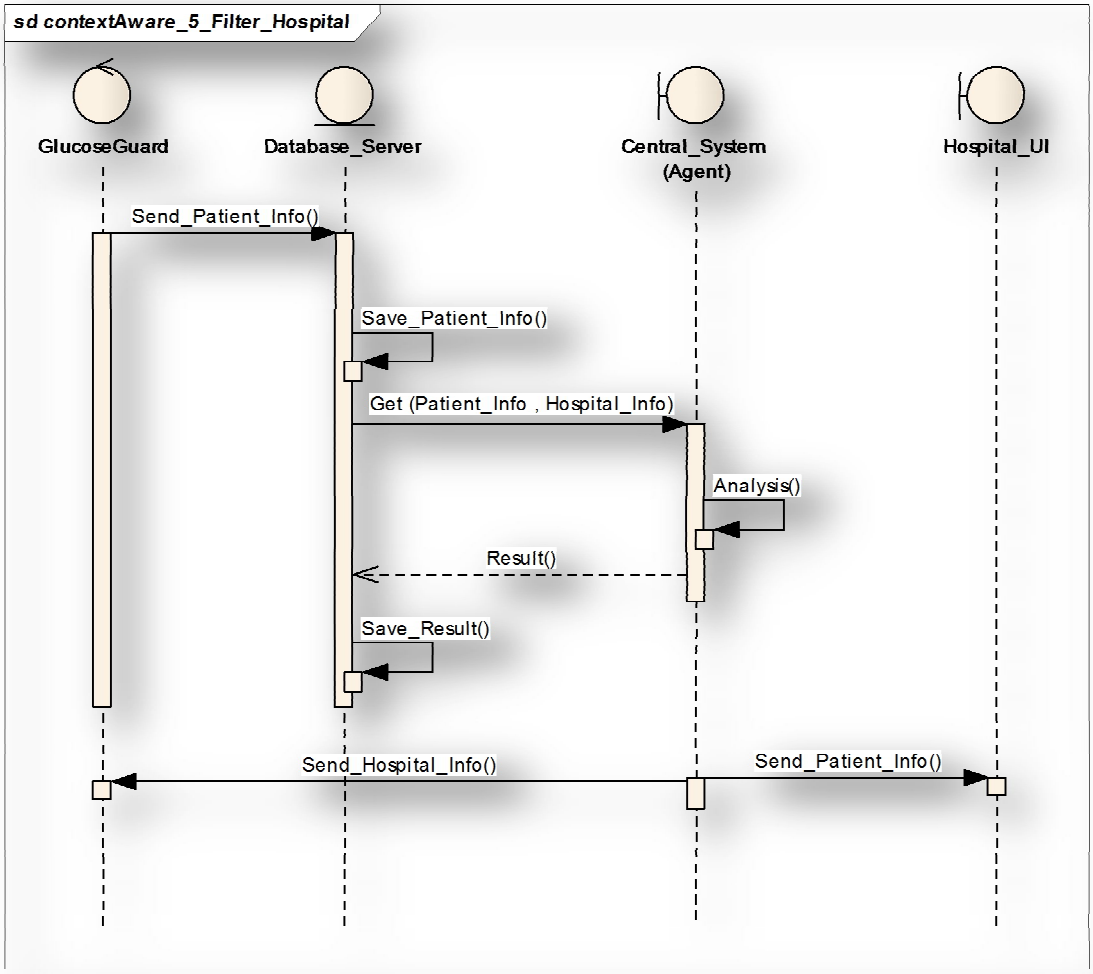
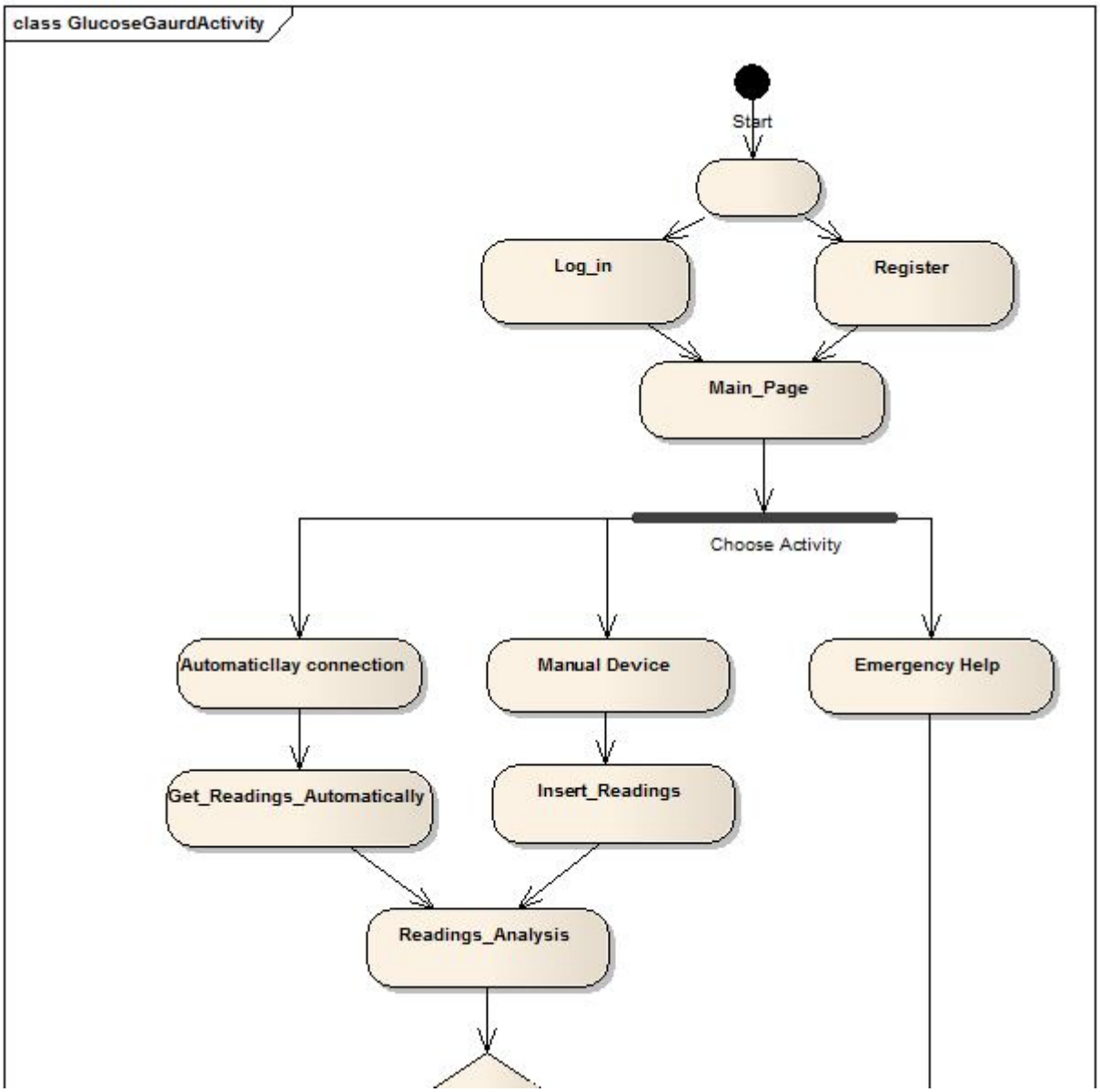


Figure 4.6: Sequence Diagram for Analyze Patient's Info & Hospital's Info use case.

4.4.3 Activity Diagrams

Activity diagram describes how system works.



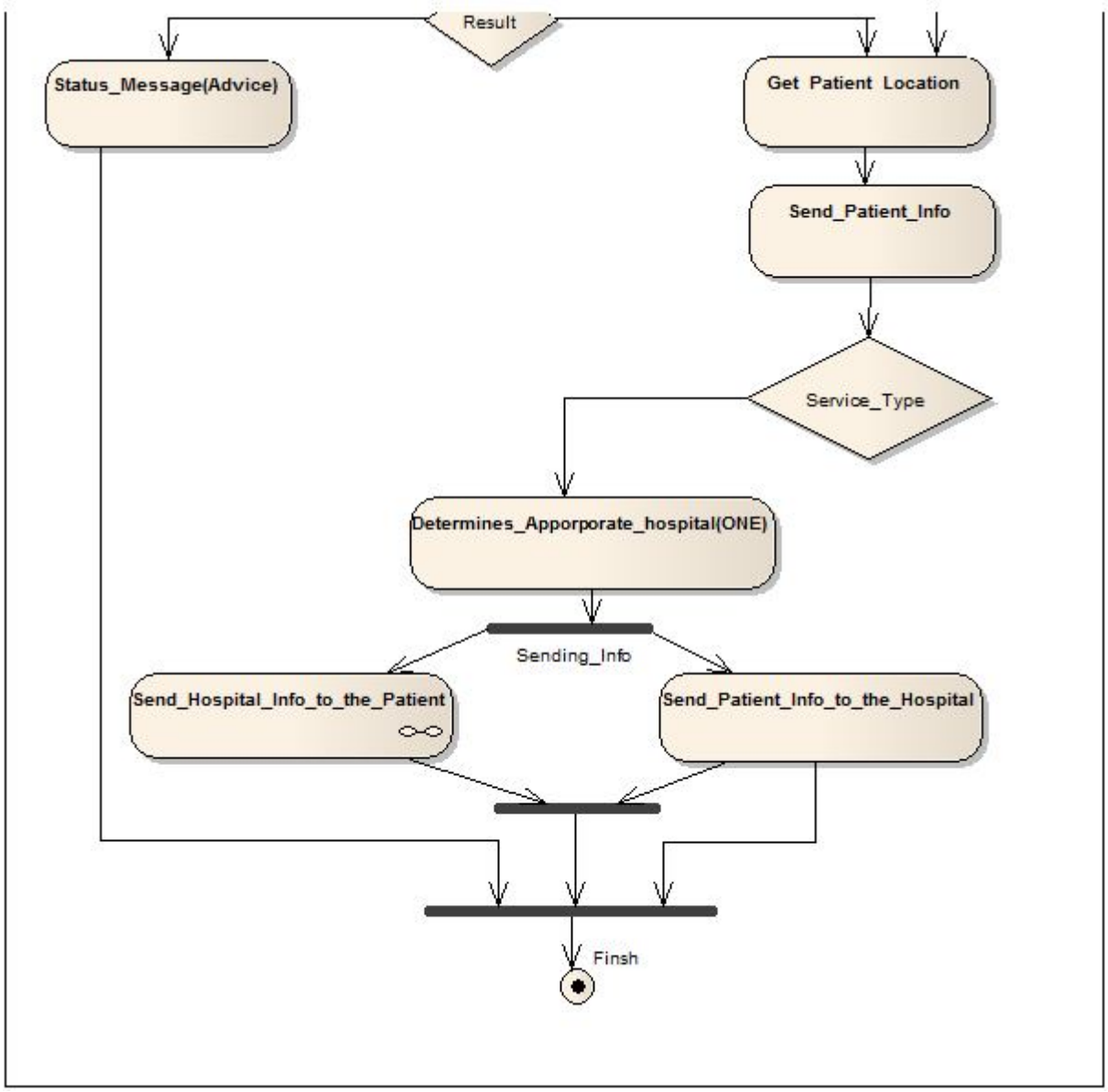


Figure 4.7: Activity Diagram for System.

4.4.4 Deployment Diagrams

Deployment diagram shows how and where the system is to be deployed.

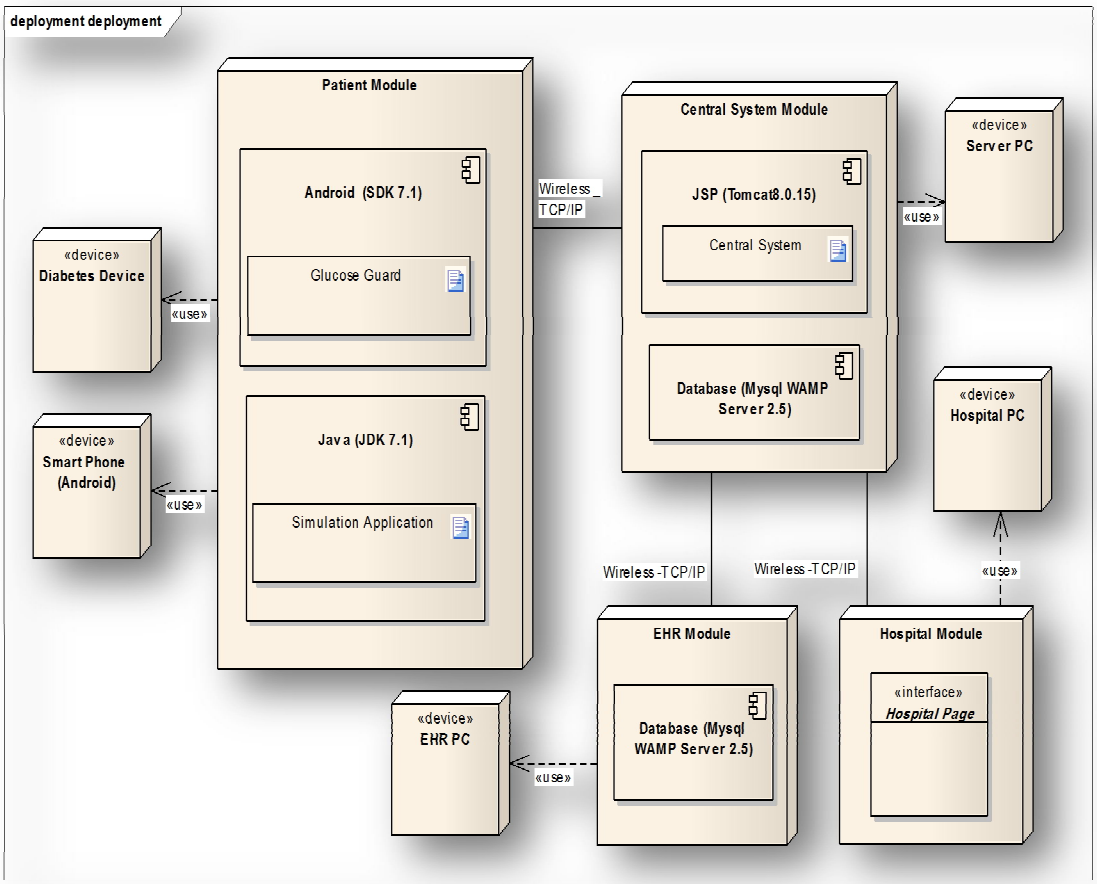


Figure 4.8: Deployment Diagram for System.

4.5 System Design

4.5.1 Class Diagrams

Class diagram shows behaviour and attributes of the system.

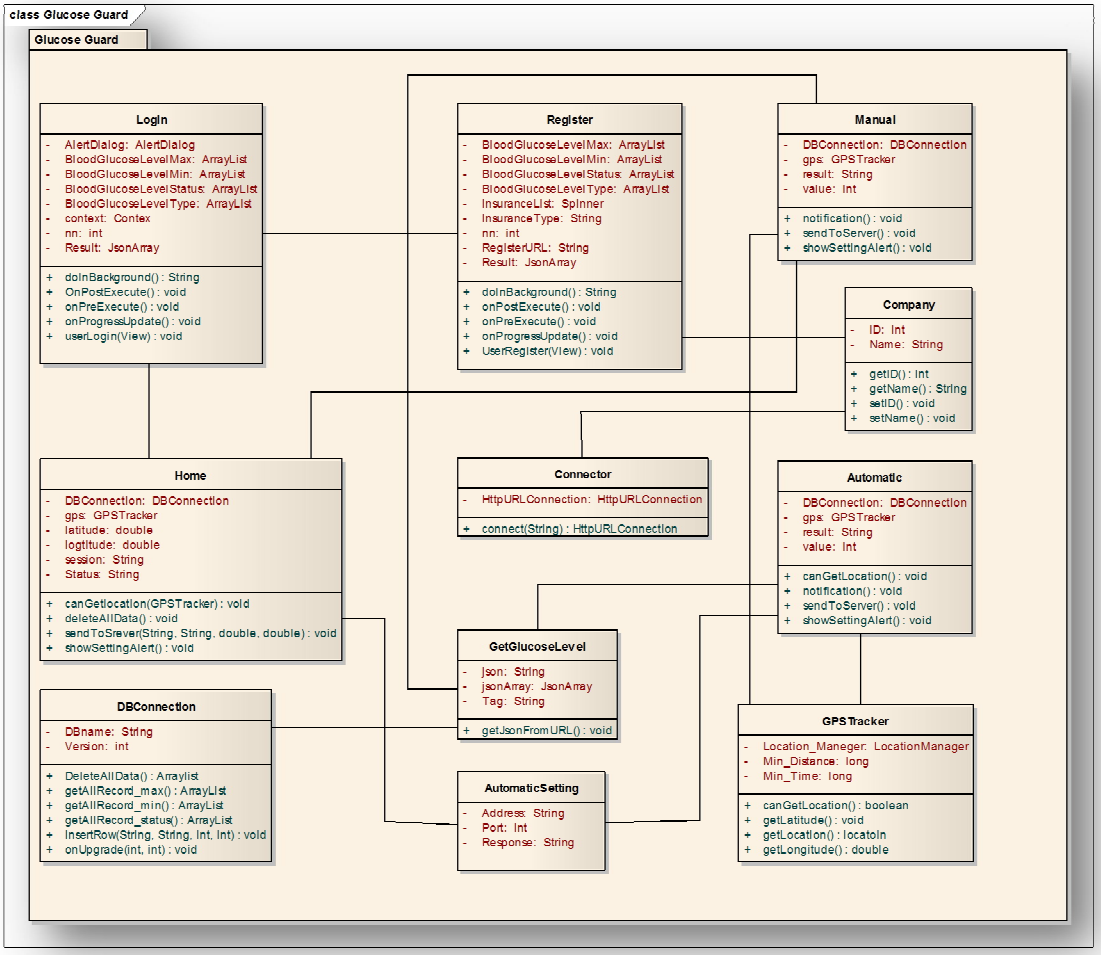


Figure 4.9: Class Diagram for Glucose Guard Application.

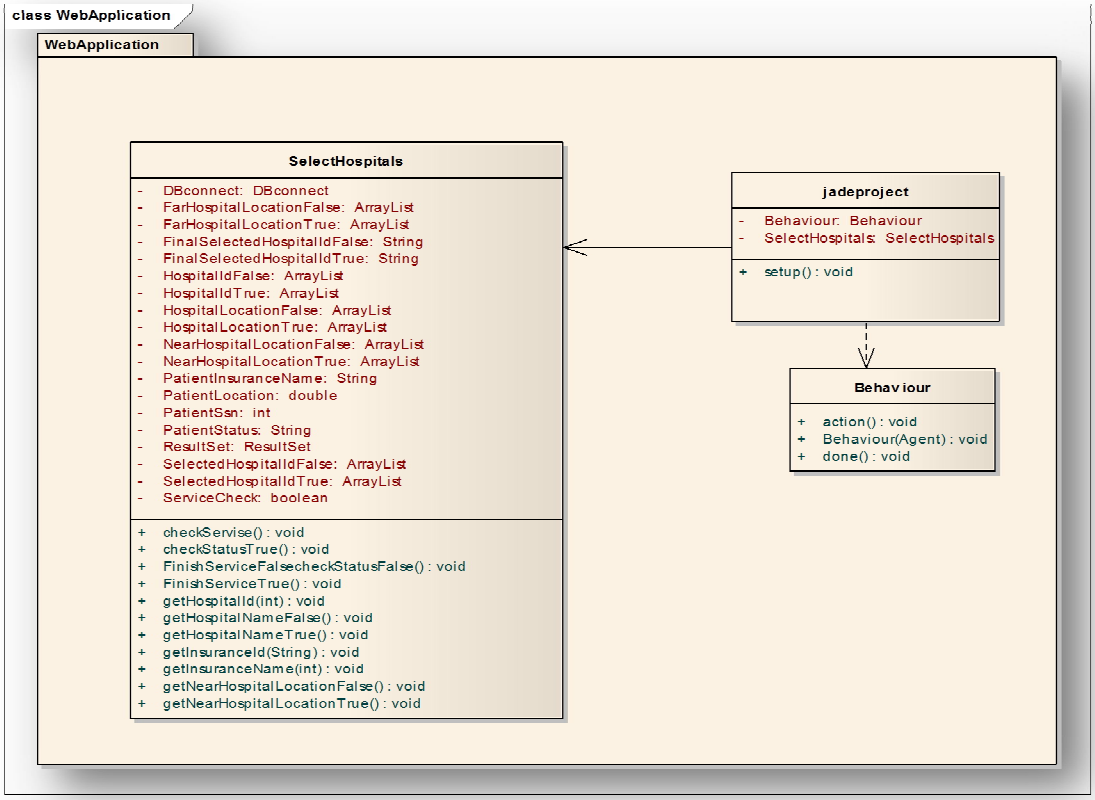


Figure 4.10: Class Diagram for Central System (Server).

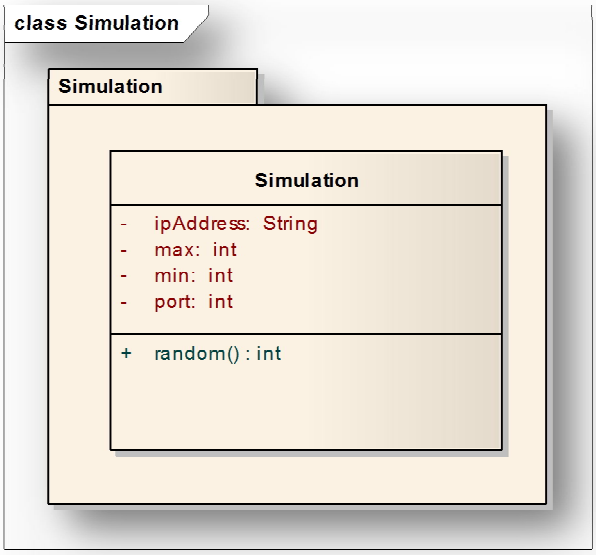


Figure 4.11: Class Diagram for Automatic Diabetes Device (Simulation).

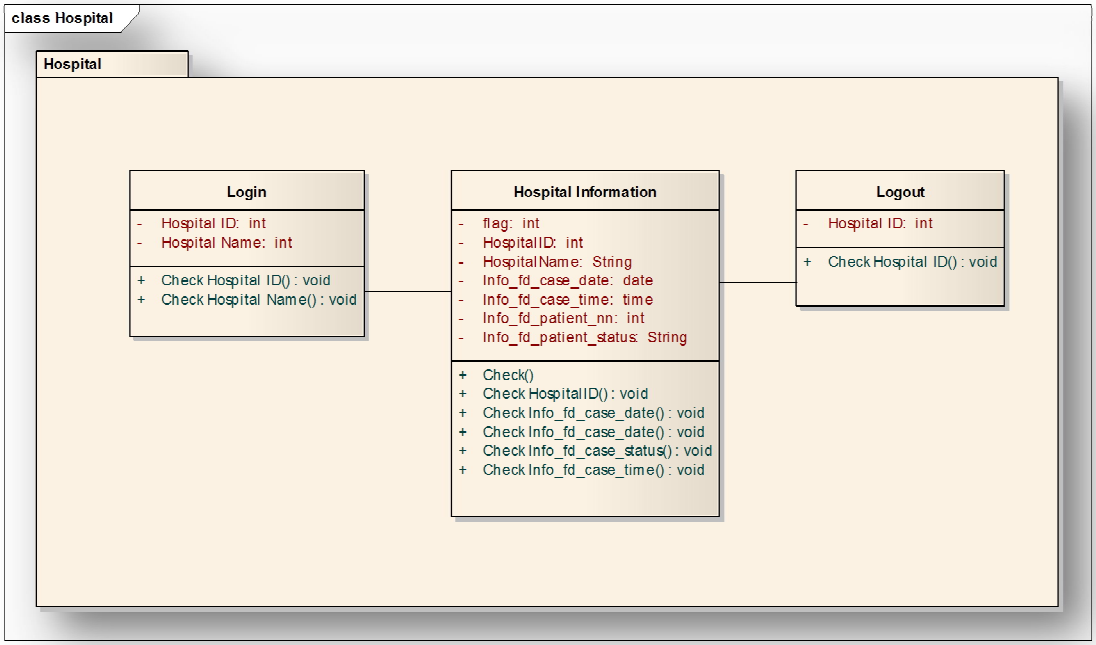


Figure 4.12: Class Diagram for Hospital.

4.5.2 Glucose Guard Database

Column Name	Data type	L	N	PK	FK	U
fd_glucose_min	Int	11	N			*
fd_glucose_max	Int	11	N			*
fd_glucose_status	Char	20	N			
fd_glucose_type	Char	20	N			

Table 4.1: cfg_glucose_level.

Column Name	Data type	L	N	PK	FK	U
pk_hospital_id	Int	11	N	*		
fd_hospital_name	Char	50	N			*
fd_hospital_location_lat	Double	50,9	N			*
fd_hospital_location_long	Double	50,9	N			*
fd_hospital_email	Char	40	N			*
fd_hospital_phone_num	Int	30	N			*
fd_hospital_emergency_num	Int	30	N			*
fd_emergency_room	Char	11	N			
fd_esoteric_department	Char	11	N			

Table 4.2: cfg_hospitals.

Column Name	Data type	L	N	PK	FK	U
fk_hospital_id	Int	11	N		*	
fk_insurance_id	Int	11	N		*	

Table 4.3: cfg_hospitals_has_insurance.

Column Name	Data type	L	N	PK	FK	U
pk_insurance_id	Int	11	N	*		
fd_insurance_name	Char	50	N			*

Table 4.4: cfg_insurance_companies.

Column Name	Data type	L	N	PK	FK	U
pk_case_id	Int	11	N	*		
fd_case_date	DATE		N			
fd_case_time	TIME		N			
fd_patient_nn	Int	20	N			
fd_patient_location_lat	Double	50,9	N			
fd_patient_location_long	Double	50,9	N			
fd_patient_status	Char	30	N			
fd_service	Char	20	N			
fd_selected_hospital_id	Int	50	N			

Table 4.5: opt_patients_emergency_case.

Column Name	Data type	L	N	PK	FK	U
pk_patient_nn	Int	20	N	*		
fd_insurance_name	Int	50	Y			

Table 4.6: opt_patients_info.

4.5.3 Database and View (EHR)

Column Name	Datatype	L	N	PK	FK	U
pk_hospital_id	Int	11	N	*		
fd_hospital_name	Char	50	N			*
fd_hospital_location_lat	Double	50,9	N			*
fd_hospital_location_long	Double	50,9	N			*
fd_hospital_email	Char	40	N			*
fd_hospital_phone_num	Int	30	N			*
fd_hospital_emergency_num	Int	30	N			*
fd_emergency_room	Char	11	N			
fd_esoteric_department	Char	11	N			

Table 4.7: cfg_hospitals.

Column Name	Datatype	L	N	PK	FK	U
fk_hospital_id	Int	11	N		*	
fk_insurance_id	Int	11	N		*	

Table 4.8: cfg_insurance_companies.

Column Name	Datatype	L	N	PK	FK	U
pk_insurance_id	Int	11	No	*		
fd_insurance_name	Char	50	No			*

Table 4.9: cfg_hospitals_has_insurance.

Column Name	Datatype	L	N	PK	FK	U
pk_patient_nn	Int	20	N	*		
fd_patient_first_name	Char	11	N			
fd_patient_mid_name	Char	11	N			
fd_patient_last_name	Char	11	N			
fd_patient_birth_date	DATE		N			
fd_patient_death_date	DATE		N			
fd_patient_gender	Char	11	N			
fd_patient_phone_num	Int	30	N			*
fd_Patient_emergency_num	Int	30	N			*
fd_patient_image	BLOB		N			

Table 4.10: opt_patients_record.

Column Name	Datatype	L	N	PK	FK	U
fk_patient_nn	Int	20	No		*	
fd_case_date	DATE		No			
fd_case_time	TIME		No			
fd_diagnosis	Char	100	No			

Table 4.11: opt_patients_diagnoses.

Column Name	Datatype	L	N	PK	FK	U
pk_hospital_id	Int	11	N	*		
fd_hospital_name	Char	50	N			*
fd_hospital_location_lat	Double	50,9	N			*
fd_hospital_location_long	Double	50,9	N			*
fd_hospital_email	Char	40	N			*
fd_hospital_phone_num	Int	30	N			*
fd_hospital_emergency_num	Int	30	N			*
fd_emergency_room	Char	11	N			
fd_esoteric_department	Char	11	N			

Table 4.10: vw_hospitals.

Column Name	Datatype	L	N	PK	FK	U
fk_hospital_id	Int	11	N		*	
fk_insurance_id	Int	11	N		*	

Table 4.11: vw_insurance_companies.

Column Name	Datatype	L	N	PK	FK	U
pk_insurance_id	Int	11	N	*		
fd_insurance_name	Char	50	N			*

Table 4.12: vw_hospitals_has_insurance.

4.5.4 Entity Relationship Diagram (ERD)

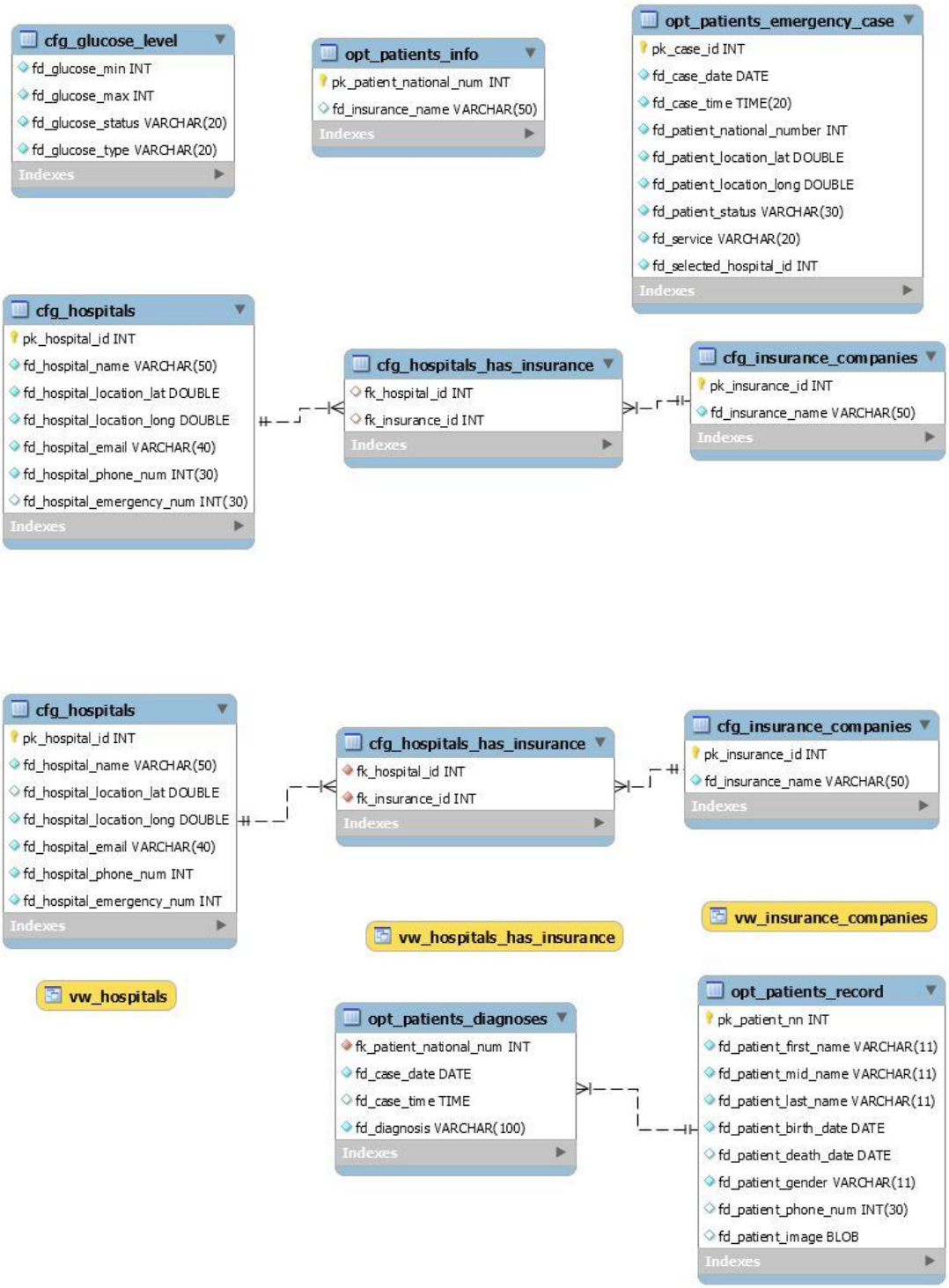


Figure 4.13: Illustrate the (ERD) of the System.

4.6 System Operations

In building context-aware hospital system (for diabetics), the first step is the availability of the diabetes device (manual or automatic) to connect with the Glucose Guard and how the readings should be delivered from the diabetes device to the Glucose Guard. The second step is to analyse the readings. The third step is to send patient information to the central system (if necessary). The forth step is that the central system determines the appropriate hospital and send patient's information to this hospital (in case of emergency). The sixth step is to inform the patient with the nearest hospital.

In our context aware hospital system, there are two main modules: patient module and central system module. Each module consists of a group of processes, which will operate according to specific input. The two modules behaviour is flowing in six basic stages which are: readings acquisition, readings analyse, context dispatch, execute server work, sending result and get record. They are depicting in figure 4.5 below.

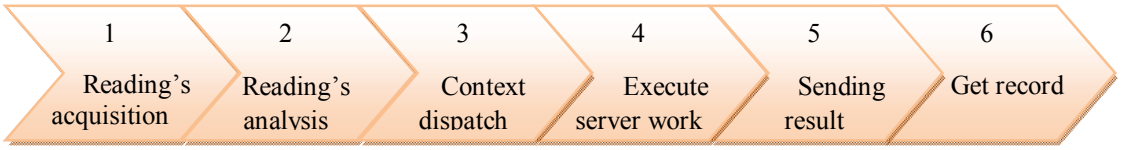


Figure 4.13: Framework's Modules.

1) Readings Acquisition

The processes in this module are responsible for acquire glucose readings whether in manual way or automatic way. The processes in this module are one of two processes as listed in (Table 4.15: Readings Acquisition Processes).

Processes
Get readings automatically.
Get readings manually.

Table 4.13: Readings Acquisition Processes.

1. **Get readings automatically**

The purpose of this process is to capture the readings from the external environment from the automatic diabetes device automatically (the diabetes device and the Glucose Guard application are connected via Wi-Fi). This process is invoked when the patient measures his glucose rate using automatic device. It receives glucose readings as inputs and then prepares it for the next stage (Table 4.16: Get readings automatically).

Input	Output	Tools/Approaches
-glucose readings.	-	-connector (Wi-Fi).

Table 4.14: Get readings automatically.

2. **Get readings manually**

The purpose of this process is to insert the readings from the external environment from normal diabetes device manually (the diabetes device and the Glucose Guard application are not connected). This process is invoked when the patient measures his glucose rate manually then inserts this reading in the application in the allocated field. It receives glucose readings as inputs and then prepares it for the next stage (Table 4.17: Get readings manually).

Input	Output	Tools/Approaches
-glucose readings.	-	-inserting field.

Table 4.15: Get readings manually.

2) Reading's analysis

The processes in this module are responsible for analyze glucose readings that obtained from the previous step. It determines whether the Glucose Guard has to connect with the central system or just alert him\her about his status. The processes in this module are listed in (Table 4.18: Reading's analysis process).

Processes
Analyze readings.
Sending message to the patient.

Table 4.16: Reading's analysis process.

1. **Analyze readings**

In this process the Glucose Guard will determine the range of the glucose whether it is in the normal range or its over\down the normal with a quite low range or its over\down the normal with high range (Table 4.19: Analyze readings).

Input	Output	Tools/Approaches
-glucose readings.	-glucose range.	-analytical method.

Table 4.17: Analyze readings.

2. **Sending message to the patient**

In this process and according to the data analysis range the Glucose Guard will send to the patient, either message to increase his/her glucose percentage or to decrease it. This process is invoked when the glucose percentage is between (80-200) OR between (201- 250) and the patient does not need to go to the hospital (Table 4.20: Sending message to the patient).

Input	Output	Tools/Approaches
-glucose range.	-alert message.	-alert channel.

Table 4.18: Sending message to the patient.

3) Context Dispatch

The processes in this module are responsible for sending patient information that obtained and analyzed from the previous steps to the web application (server). In this module the Glucose Guard will gather the suitable data related to the patient and send it. The processes in this module are listed in (Table 4.21: Context dispatch Processes).

Processes
Determine patient location.
Sending patient info to central system.

Table 4.19: Context dispatch Processes.

1. Determine patient location

This process is about determining patient location as a part of patient information which is delivered to the central system (server) (Table 4.22: Determine patient location).

Input	Output	Tools/Approaches
-	-patient location.	-GPS.

Table 4.20: Determine patient location.

2. Sending patient info to central system

In this process, according to the data analysis range the Glucose Guard application will send the patient information to the central system (server). This process is invoked when the glucose percentage is quite low or high (Table 4.23: Sending patient info to central system).

Input	Output	Tools/Approaches
-glucose readings.	-patient info.	-detection method. -connection with server.

Table 4.21: Sending patient info to central system.

4) Execute Server Work

This module is responsible for most of the work. The processes in this module began from receiving patient's information and ended with sending back hospital offer to the Glucose Guard. The processes in this module are listed in (Table 4.24: Execute server work Processes).

Processes
Determine appropriate hospital.
Informing hospital with patient condition.

Table 4.22: Execute server work Processes.

1. Determine appropriate hospital

In this process, according to the patient location and insurance type the central system will determine the appropriate hospital. This process is invoked when the central system delivered the patient information (Table 4.25: Determine appropriate hospital).

Input	Output	Tools/Approaches
-patient location.	-one hospital.	-searching technique (Agent/JADE).

Table 4.23: Determine appropriate hospital.

5) Sending Result to the Patient

The process in this module is responsible for sending hospital offers to Glucose Guard. The process in this module as in (Table 4.26: Sending result to the patient**).**

Processes
-send hospital offers

Table 4.24: Sending result to the patient.

1. Send hospital offers

In this process, central system send hospital offer to the Glucose Guard (Table 4.27: Send hospital offer).

Input	Output	Tools/Approaches
-hospitals name. -hospital offer.	-hospital offer.	-Connection with Glucose Guard.

Table 4.25: Send hospital offer.

6) Sending Result to the Hospital

The process in this module is responsible for sending patient's information to selected hospital. The processes in this module are listed in (Table 4.28: Sending result to the hospital).

Processes
-send patient's information.

Table 4.26: Sending result to the hospital.

1. **Send patient's information**

In this process, central system send patient's National Number and other related information to the selected hospital to get his\her medical record, (Table 4.29: Send patient information).

Input	Output	Tools/Approaches
-patient's National Number and other related information.	-patient's record.	-connection with hospital.

Table 4.27: Send patient information.

4.7 Summary

In this chapter represent functional and non-functional requirements, also analyze of the system using UML diagrams, also design of database. Finally determine System operations by identify system modules and its process.

Next chapter will show the implementation of the system and the output s for all modules.

Chapter Five: Implementation & Validation

5.1 Introduction

This chapter shows the implementation steps and some of system screens which illustrate the functionality of the system.

5.2 System Implementation

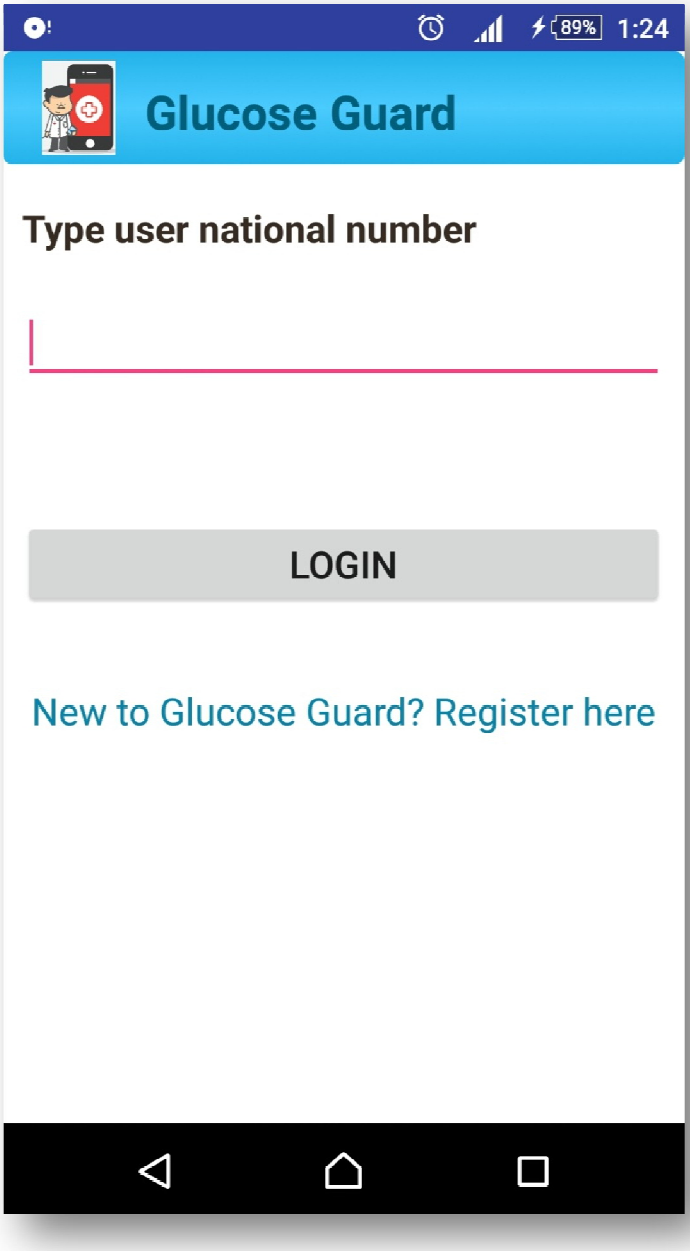


Figure 5.1: Login Screen.

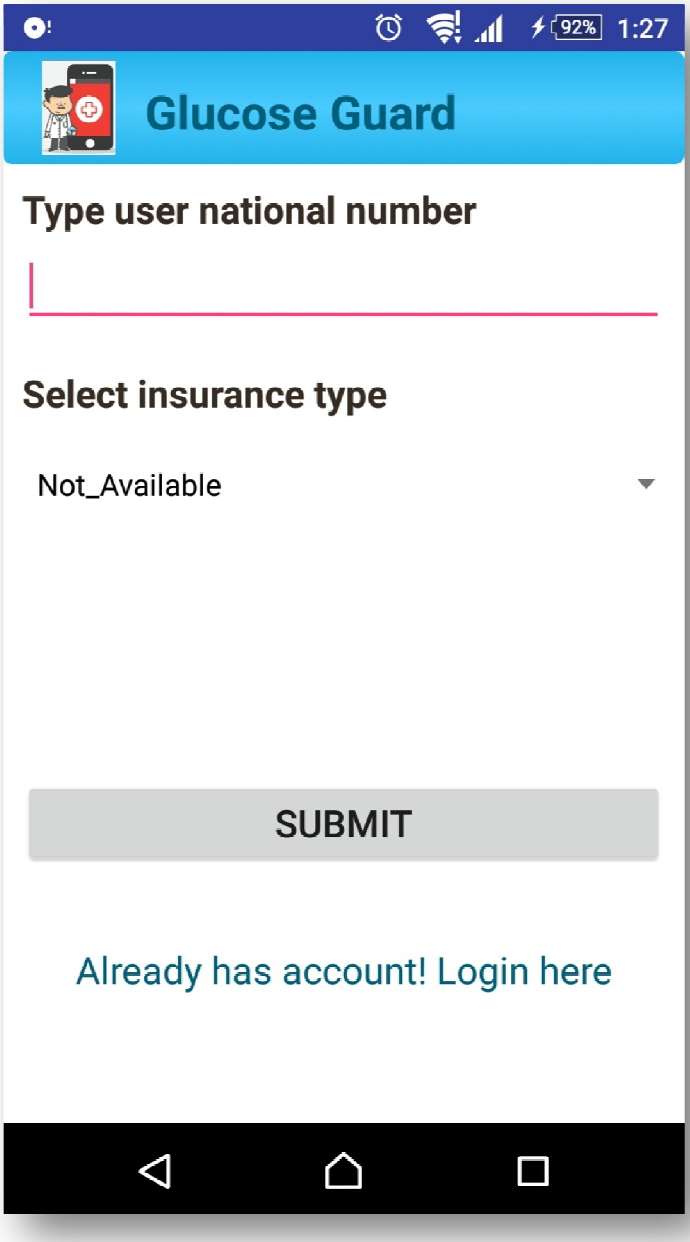


Figure 5.2: Registration Screen.

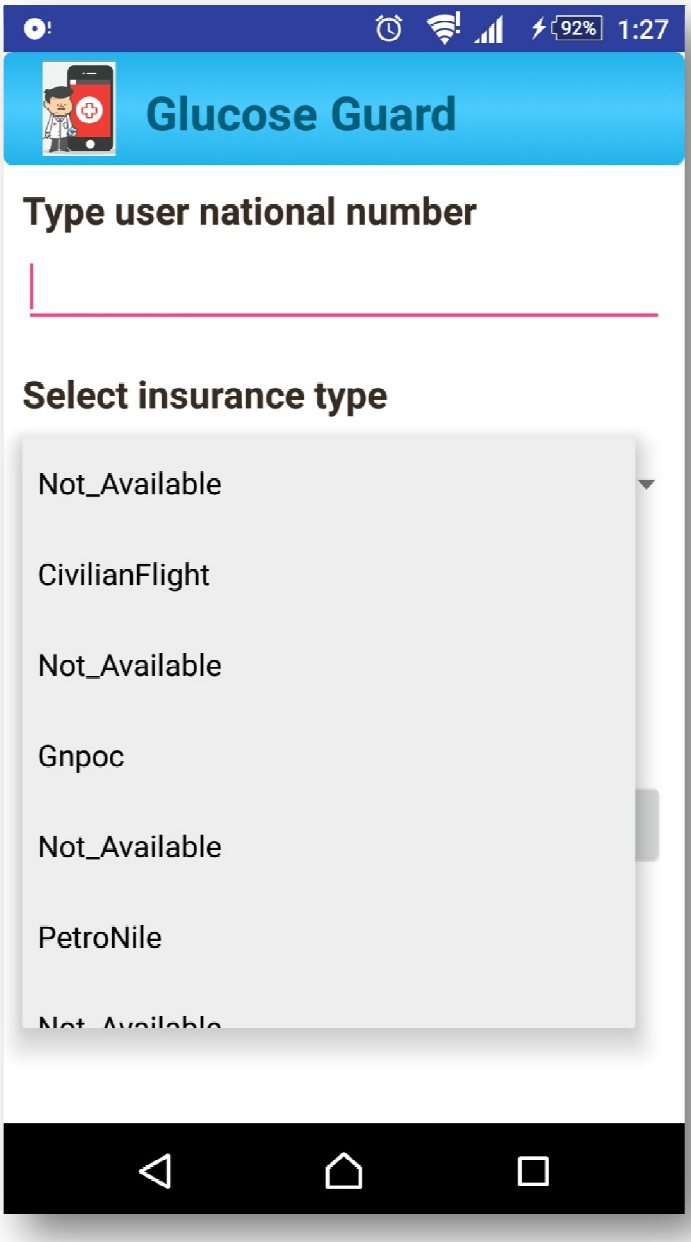


Figure 5.3: Registration screen with dropdown insurance list.

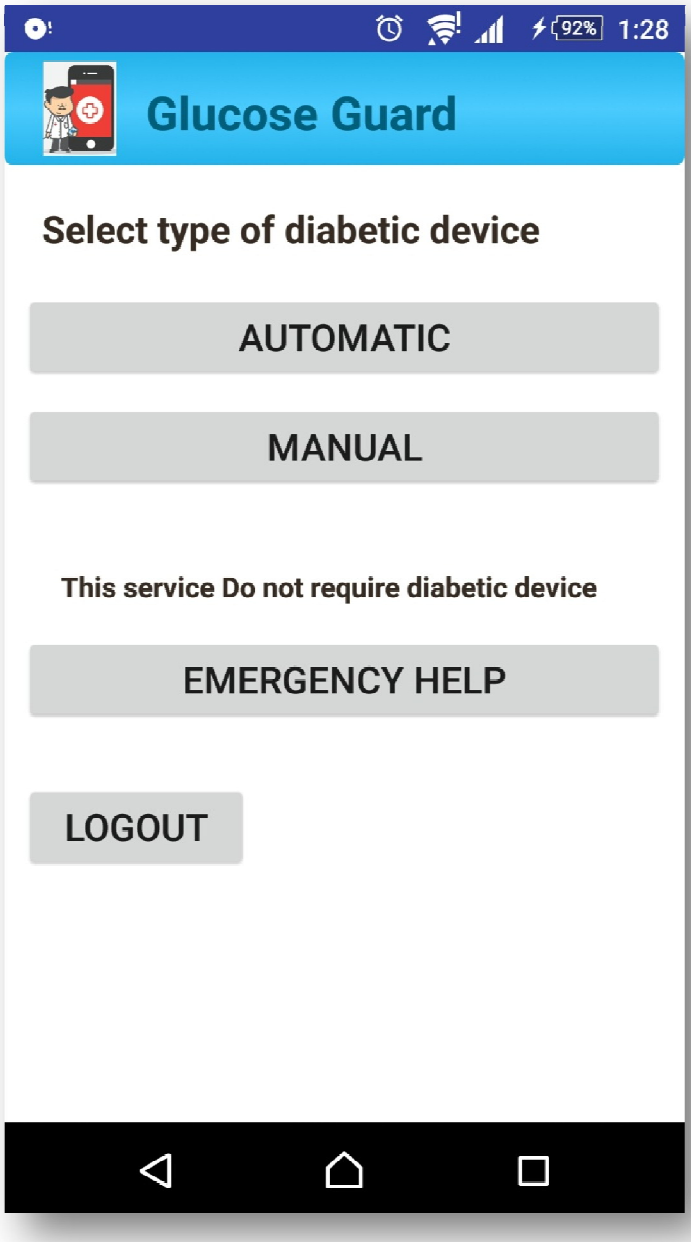


Figure 5.4: Home Screen.

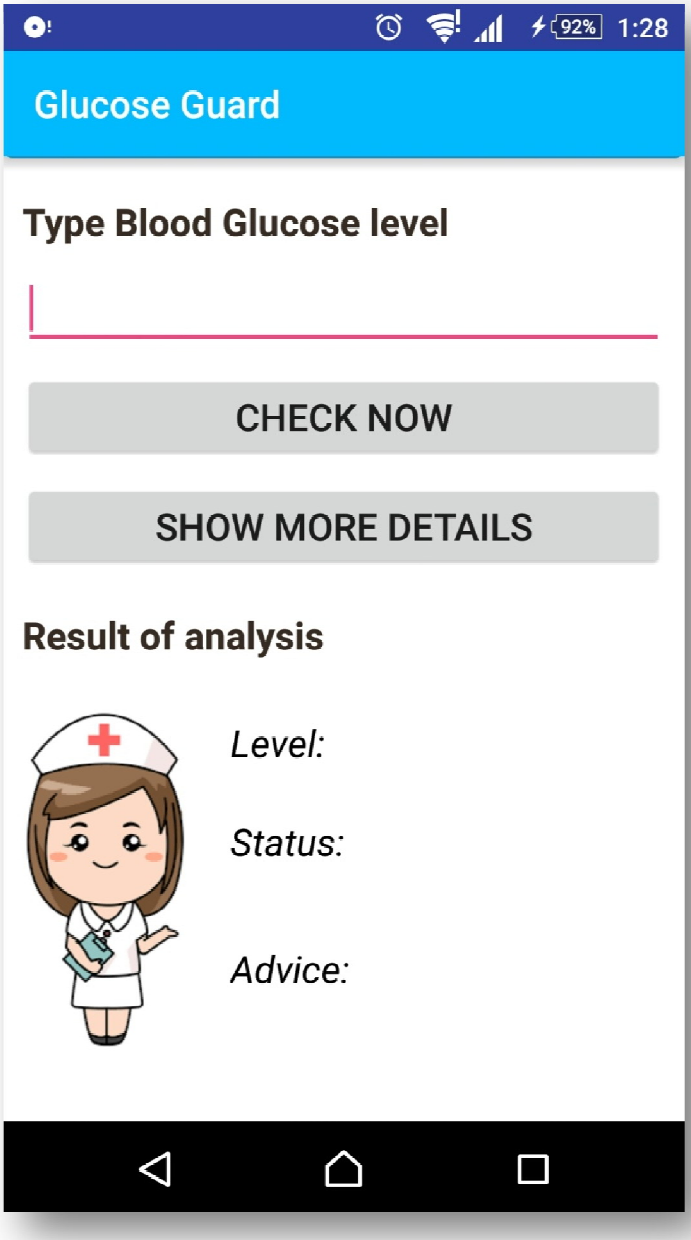


Figure 5.5: Manual Diabetic Device Screen.

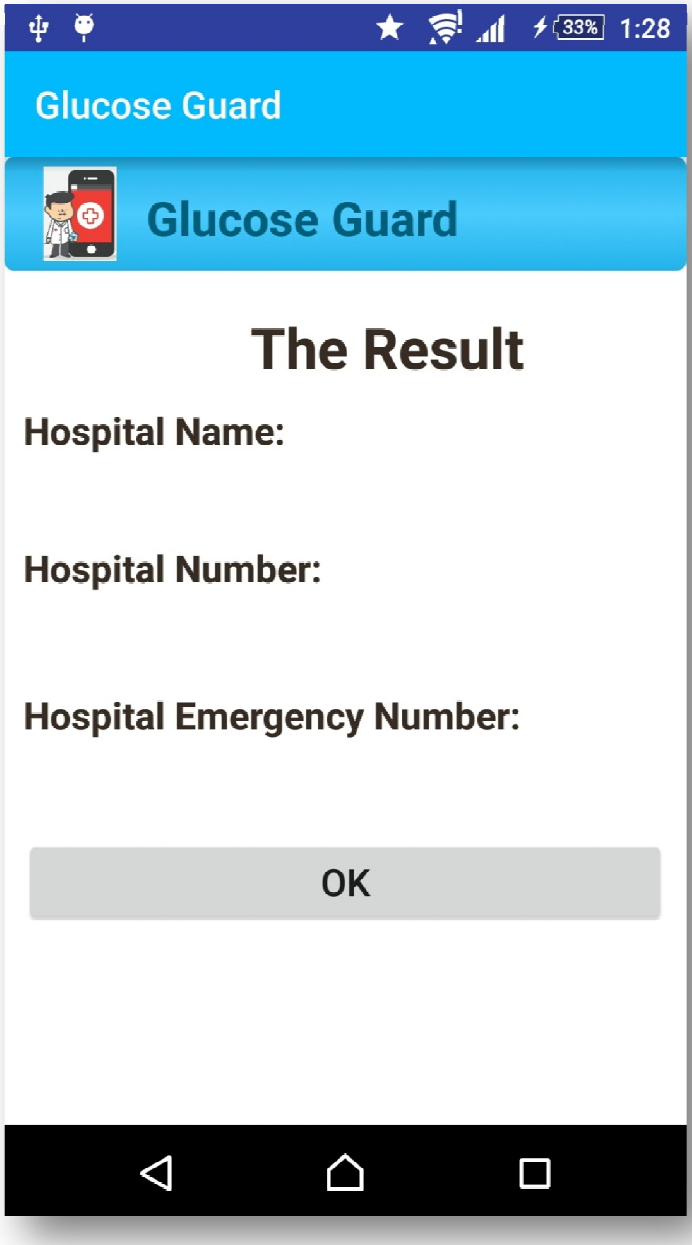


Figure 5.6: Result Screen.

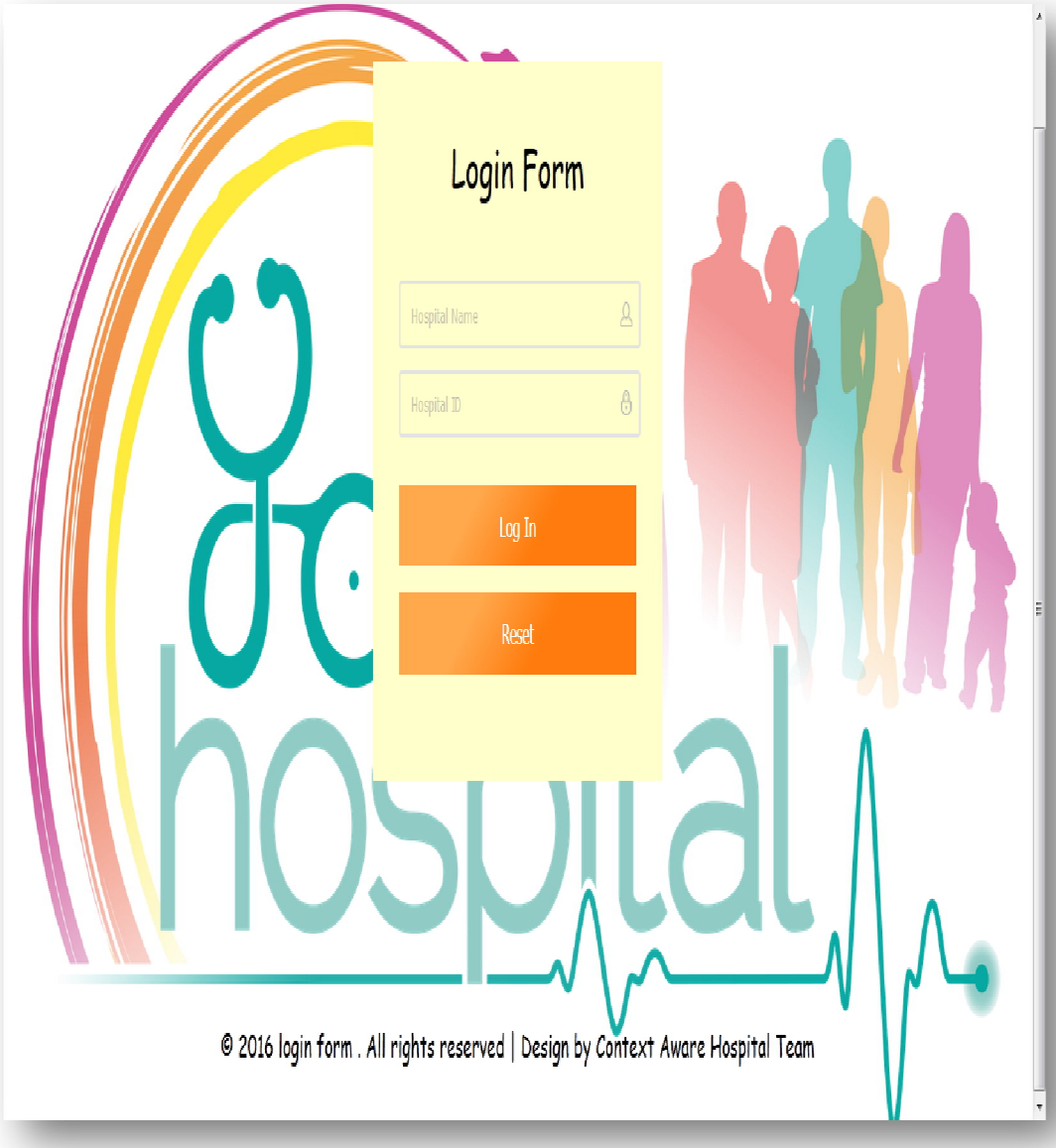


Figure 5.7: Hospital login page.

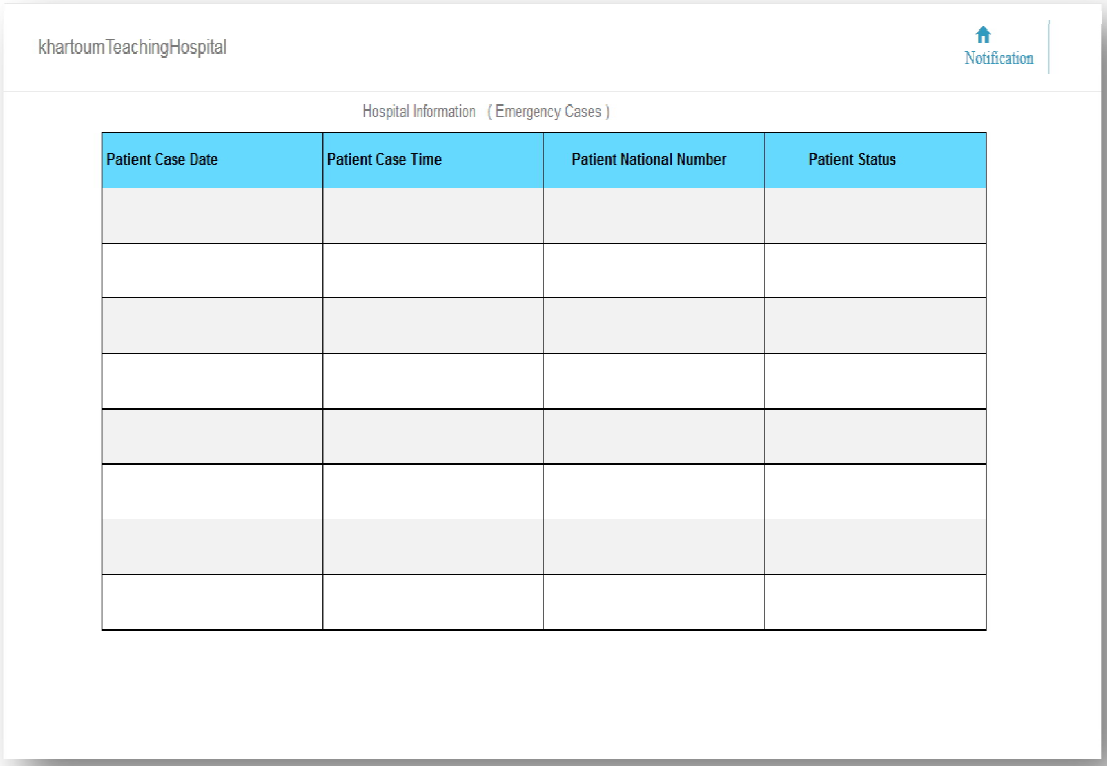


Figure 5.8: Hospital Notification Page.

5.3 Result and Validation

The first step the user types his National Number, then the Glucose Guard application verified his/her account, if it was valid then move him/her to the Home page, otherwise ask him/her to make sure his/her account or Register to the Glucose Guard application.

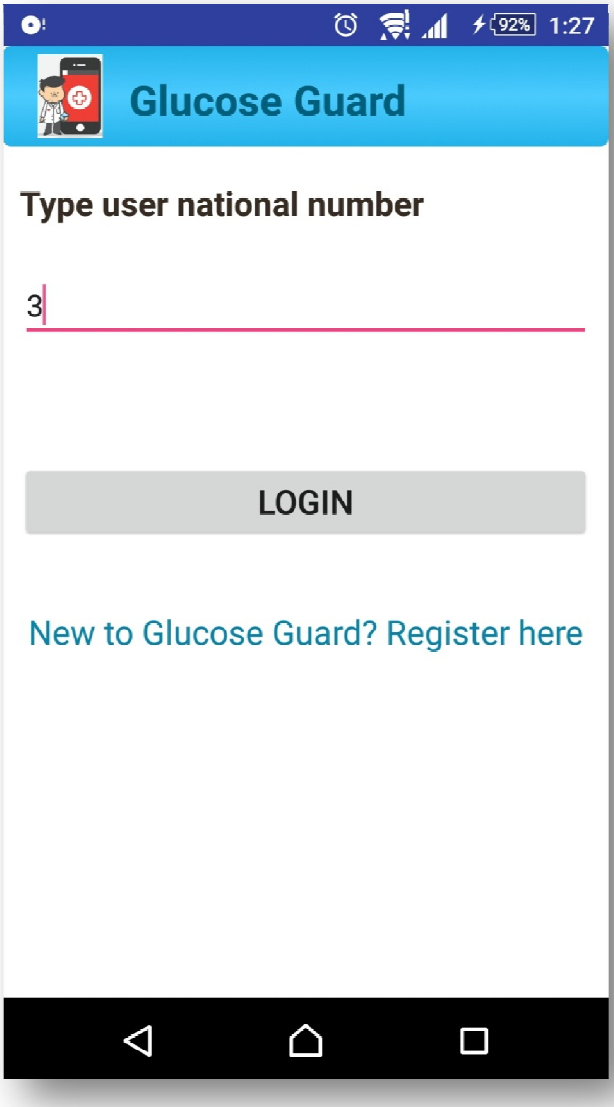


Figure 5.9: User types his/her National Number to Login to Glucose Guard application.

In this step the user types his/her National Number and select his/her insurance type if he/she has an insurance, in the case of he/she has not an insurance select the not available option, then the Glucose Guard save his/her information and move him/her to the Homepage.

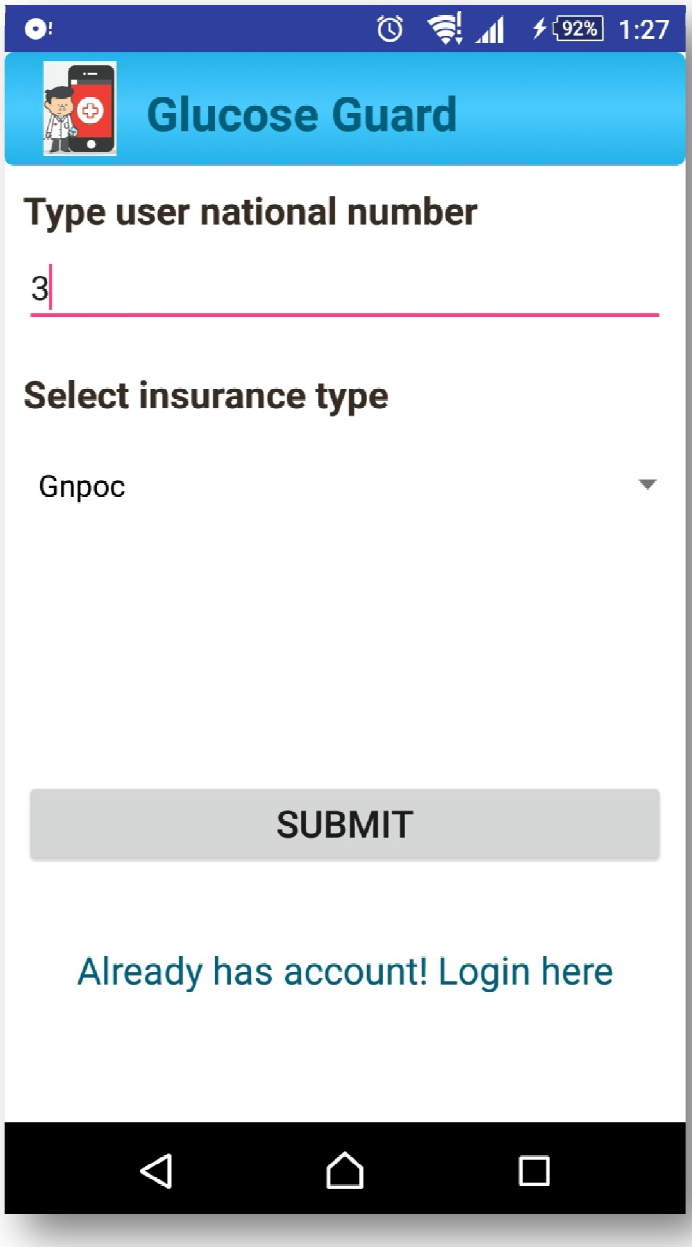


Figure 5.10: User types his/her National Number to register to Glucose Guard application.

In this step the user types his/her blood glucose level in the allocated felid and press check to get the result of analysis, there are different type of result and we are illustrate them in the following figures. The user can press show more details button to obtain more detail about nearest hospital.

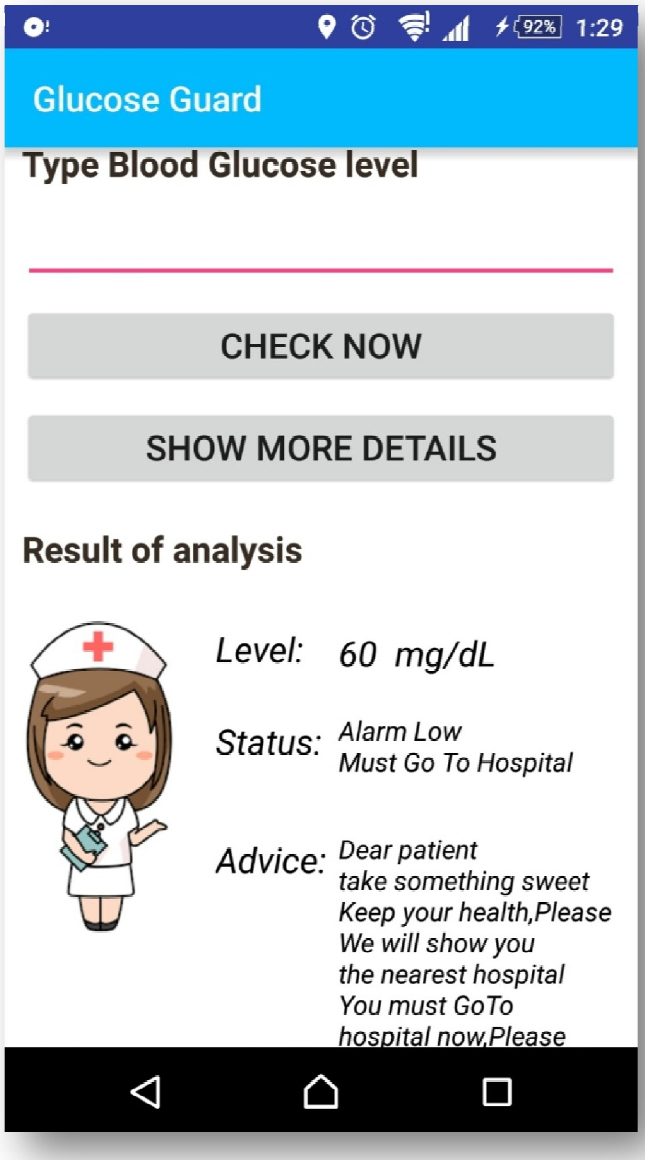


Figure 5.11: User types his/her blood glucose level and press check to see the result (Low Range).

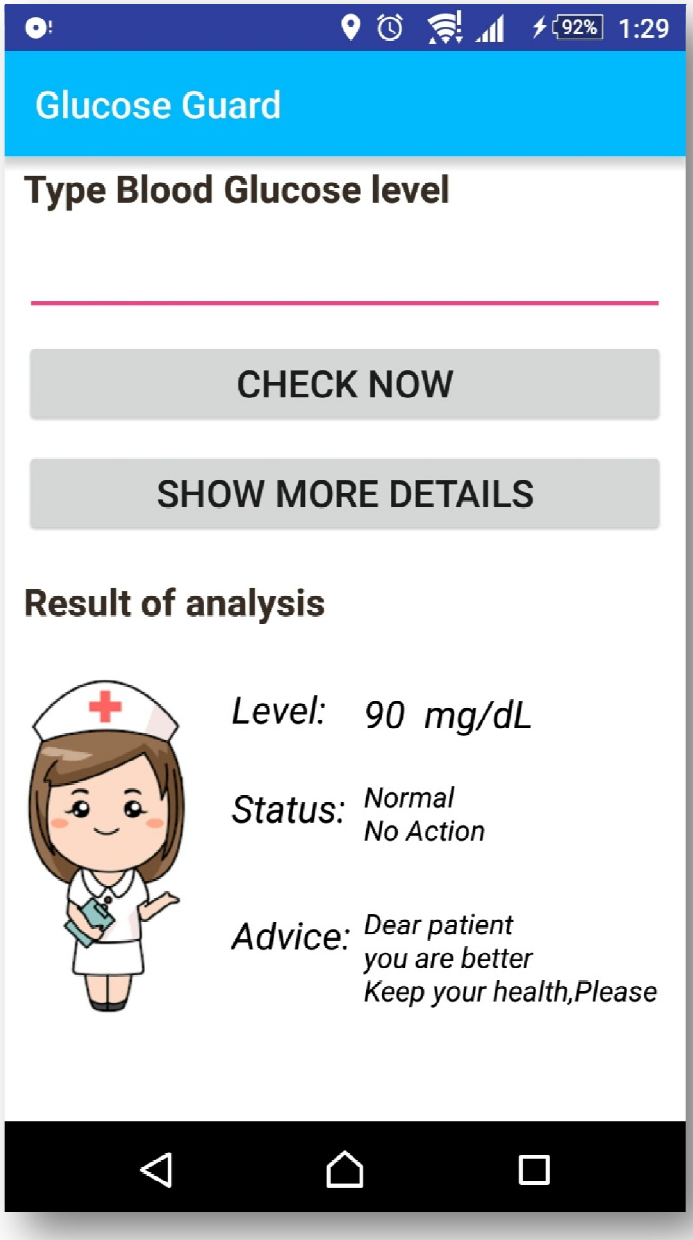


Figure 5.12: User types his/her blood glucose level and press check to see the result (Normal Range).

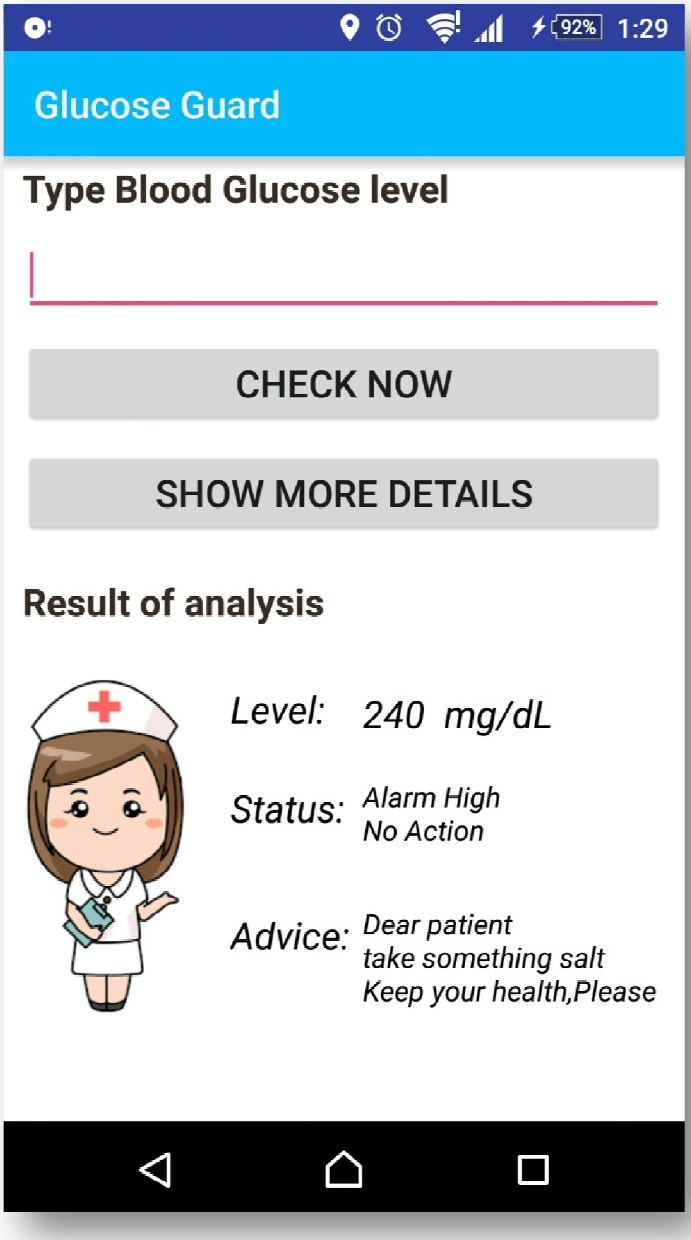


Figure 5.13: User types his/her blood glucose level and press check to see the result (High Range)

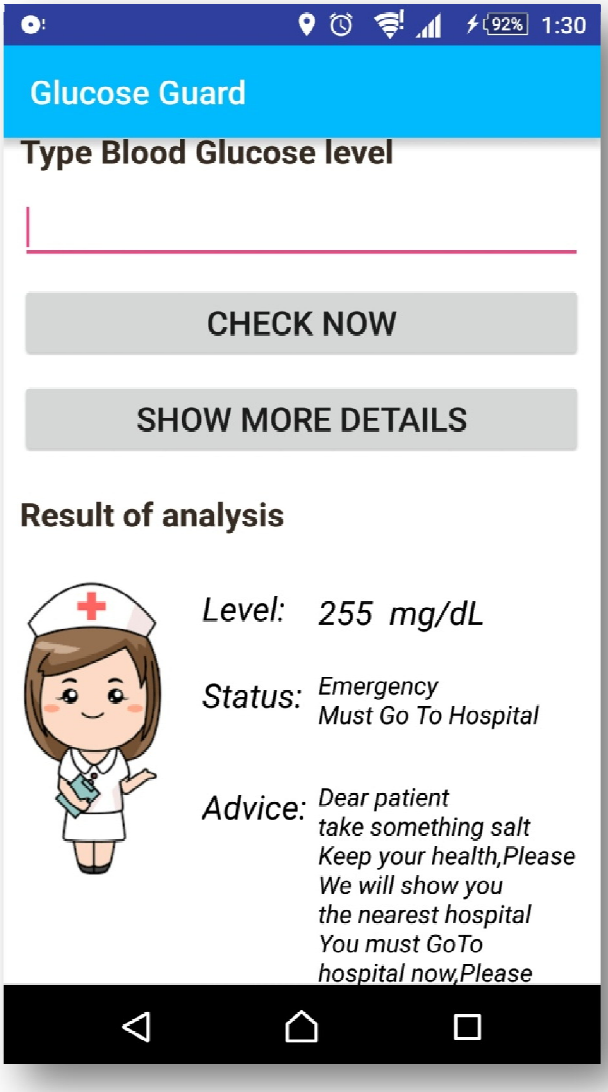


Figure 5.14: User types his/her blood glucose level and press check to see the result (Emergency Case).

In the result step the patient get the information about nearest hospital that the central system (server) selected it based on his/her information, in case of emergency and Help.

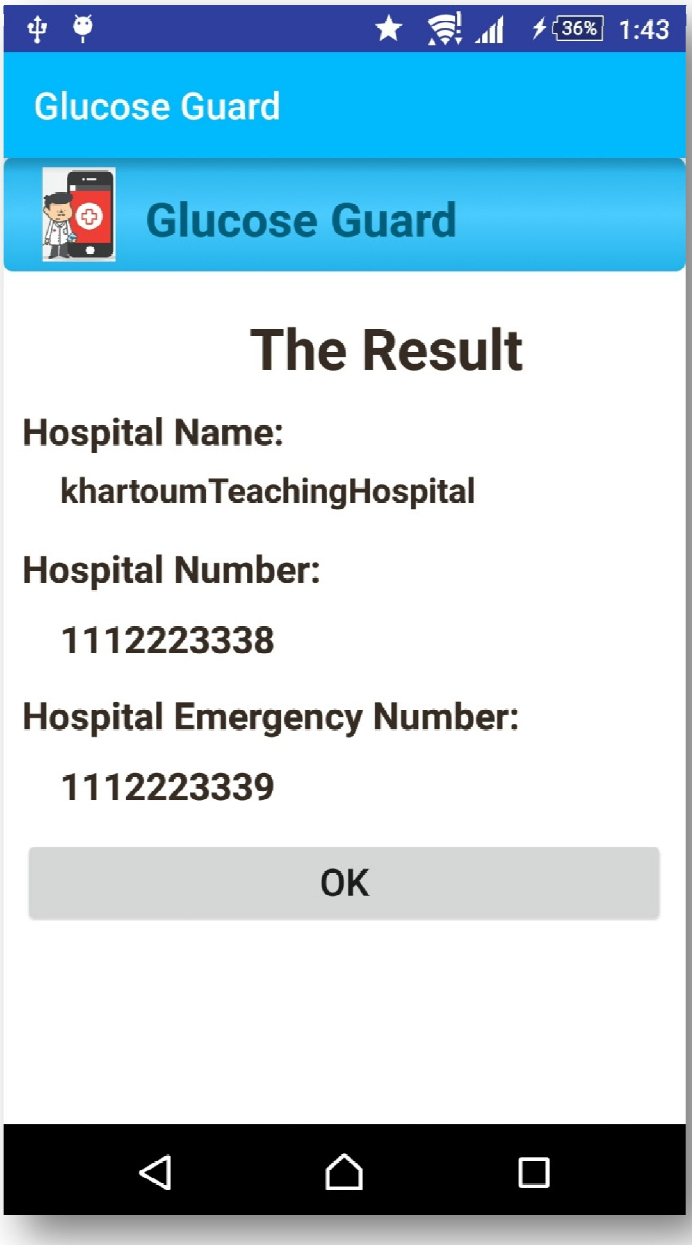


Figure 5.15: Get the Result from Central System (Server) to Patient Glucose Guard Application (Only One Hospital) in Case of Emergency and Help.

The first step the hospital types its name and ID, and then the central system (server) verified its account, if it was valid then sends it to its page, otherwise ask it to make sure the account.

Figure 5.16: Hospital types its (Name and ID) in login page.

In this step the hospital, all patient notification will be displayed in the allocated table, to deal with them.

Figure 5.17: Hospital notification page.

5.4 Summary

In this chapter we showed system screens and how the system works in both modules Glucose Guard and hospital modules.

In the next chapter we will present the result of our system and obstacles that faced us and the recommendations that we wish from the next developers to continue on it.

Chapter Six: Conclusions & Recommendations

6.1 Introduction

At the earliest chapters of this research, we showed the main contribution of our system and the services provided by it according to the goals that we determine at the first chapter. We came out with a result that fulfils our goals.

In this chapter we will discuss the result of the system, recommendations and obstacles that faced the development of the project.

6.2 Research Conclusions

- We simulate the work of the automatic diabetes device.
- We develop AGENT software to increase the efficiency of the system works.
- We developed Android system consist of three parts:
  - **Automatic:** For user who owns automatic diabetes device and can be connected via Wi-Fi with android system and that's lead to increase user awareness of his health condition.
  - **Manual:** For user who owns Manual diabetes device, that's leaded to expand the use of system services.
  - **Emergency HELP:** Service helps the user to find out the nearest hospital from user's location and details of this hospital.
- We designed EHR database system.
- We integrated the EHR database system with central system.
- We integrated the simulation of automatic diabetes device with android system via Wi-Fi.
- We integrated the android system with central system.
- We determined user location by using GPS technology.
- System analysis:
  - Analysed blood sugar level readings using Android system.
  - Analysed nearest hospital using AGENT software in central system.
- Sends patient’s information to the selected hospital.

6.3 Obstacles

In developing our proposed system we have faced some issues that are stands in our way, which are as listed:

- We didn't find the automatic diabetes device so we simulated its work's way.
- The large amount of required information (patient-in and patient-out) the hospital, so we just worked on the (patient-out) the hospital section.
- Slowness of android studio.
- System's hosting.

6.4 Recommendations

The project needs improvement in many aspects, some of the most required features are:

- The overall picture of the system was to develop context aware hospital which contains two services (patient-in and patient-out) the hospital.
- We have developed only the patient out service and we hope that developers will continue where we stopped and build the second service (patient-in hospital).
- Another recommendation we hope to expand the scope of the system to cover wide range of diseases.
- Also we recommend making the system in Arabic language.

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