# A MOBILE PHONE BASED MEDICATION REMINDER SYSTEM USING CLOUD COMPUTING

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HASSAN BELEID MUAMER MOHAMMED

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**Approval of the Graduate School of Applied Sciences**

**Prof. Dr. İlkay Salihoğlu**
**Director**

We certify this thesis is satisfactory for the award of the Degree of Master of Science in Computer Information Systems

Examining Committee in charge:

Prof.Dr.Rahib Abiyev, Committee Chairman, Computer Engineering Department, NEU

Prof.Dr.Dogan Ibrahim, Supervisor, Computer Information Systems Department, NEU

Assos.Prof.Dr.Nadire Cavus, Committee Member, Computer Information Systems Department, NEU

**Assist.Prof.Dr. Boran Şekeroğlu,** Committee Member, Information Systems Engineering Department, NEU

**Assist.Prof.Dr.** Samet Biricik, Committee Member, Electrical & Electronic Engineering Department, EUL

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Name, Last name: HASSAN MOHAMMED

Signature:

Date: 7/OV2016

To my parents...

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## ABSTRACT

Any living being can be a patient, which may include human beings, animals, pets, etc. The patients under human being category may include businessman, social actors, political leaders, teachers, scholars, etc. These people may busy in their everyday routine life schedule. If they are supporting from any kind of disease/illness, then it's their responsibility to get the right medicines in proper quantity at the right time. In this thesis a mobile reminder system for helping patients to medication adherence was developed. Thus, for example, with the help of the developed system patient can easily take their medication prior to the medication time with the help of the alarm. The developed system has the advantage that it is low-cost as it works on a standard PC and does not require any additional hardware. Tests carried out by the author have shown that the system could help the patient to take their medication easily and efficiently. The system described in this thesis can be developed further by developing the same application for other operating systems such iOS, and it is possible to make the being operated by the doctor via his/her mobile phones.



***Keywords:*** Mobile reminder, medication adherence application, non-adherence, patient, doctor, alarm

## ÖZET

Her yaşayanlar, insanlar ve hayvanlar vs dahil hasta olabilirler. Hasta olan insanlar iş adamı, sosyal aktör, politik idareci, öğretmen vs ve olabilirler. Bu insanlar günlük hayatlarında çok meşgul olmuş olabilirler. Eğer hasta olup ilaç alamları gerekirse doğru ilacı doğru zamanda almak kendi sorumluluklarıdır. Bu tezde, hastalara doğru zamanda doğru ilacı almaları için mobil bir sistem tasarımından bahsedilmektedir. Örneğin, geliştirlmiş olan sistem sayesinde hasta insan sistemin verdiği uyarı zamanlarınfa ilaçlarını alabilir. Geliştirlmişs olan sistemin en önemli avantajları çok ucuza mal oluşu, herhangibir standart PC de çalışabilmekte ve başka donanıma ihtiyaç olmamasıdır. Yazar tarafından yapılmış olan testlerde geliştirilmiş olan sistemin hastalara doğru ilacı zamanında almalarına ve yanlış ilaç almamalarına yardım ettiği gözlemlenmiştir. Bu tezde geliştirilmiş olan sistem daha çok geliştirilip daha faydalı yapılabilir. Örneğin, iOS gibi diğer işletim sistemlerine uyumlu sistem geliştirilebilir. Bu sistemler doktorların da yardımıyla hastalara doğru ilacı zamanında almalarına yardımcı olmuş olur ve hastalara verilen mobil telefonların doktorlar tarafından çalıştırılmasını da sağlayabilir.



*Anahtar kelimeler:* mobil hatırlatıcı, ilaç hatırlatma uygulaması, hasta, doktor, uyarı

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| | |
|---|---|
| **lG:** | First Generation |
| **2G:** | Second Generation |
| **ACID:** | Automatic Consistency Integration of Database |
| **ADE:** | Adverse Drug Events |
| **ADR:** | Adverse Drug Reactions |
| **ADT:** | Android Development Tools |
| **AMPS:** | Advanced Mobile Phone Service |
| **AMR:** | Advanced Medication Reminders |
| ANN: | Artificial Neural Network |
| **API:** | Application Programming Interfaces |
| **APK:** | Android Package. |
| **ARM:** | Annotated C++ Reference Manual |
| **BaaS:** | Backend as a Service |
| **CDMA:** | Code Division Multiple Access |
| **CDSS:** | Clinical Decision Support Systems |
| **CPOE:** | Computerized Physician Order Entry |
| **DATATEC:** | DataTech |
| **DS:** | Data Synchronization |
| **EDGE:** | Enhanced Data for GSM Evolution |
| **Emod:** | Electronic management of diabetes |
| **EMR:** | Electronic Medical Records |
| **GCM:** | Google Cloud Message |
| **GPRS:** | General Packet Radio Service |
| **GSM:** | Global System for Mobile Communications |
| **HMO:** | Health Maintenance Organizations |

| | |
|---|---|
| **HSCSD:** | High-Speed Circuit-Switched Data |
| **IDE:** | Integrated Development Environment |
| **IDEN:** | Integrated Digital Enhanced Network |
| **IOS:** | !Phone Operating System |
| **ISPOR:** | International Society for Pharmacoeconomics and Outcome Research |
| **JAR:** | Java Archive |
| **JDK:** | Java Development Kits |
| **JSON:** | JavaScript Object Notation |
| **JVM:** | Java Virtual Machine |
| **LED:** | Light Emitting Diode |
| **ME:** | Medication Errors |
| **MMA:** | Medication Management Apps |
| **OCR:** | Optical Character Reader. |
| **OHA:** | Open Handset Alliance |
| **OMA:** | Open Mobile Alliance |
| **OS:** | Operating System |
| **OSS:** | Operation Support System |
| **OTC:** | Over-the-Counter |
| **PDA:** | Personal Digital Assistant |
| **PHO:** | Personal Health Device |
| **PHR:** | Personal Heath Record |
| **QoC:** | Quality of Care |
| **RSS:** | Really Simple Syndication |
| **SDK:** | Software Development Kit |
| **SMR:** | Simple Medication Reminders |
| **SMS:** | Short Message Service |

**SQL:** Structured Query Language

**TOMA:** Time Division Multiple Access

**W-CDMA:** Wideband Code-Division Multiple-Access

**WiFi:** Wireless Fidelity

**XML:** Extensible Markup Language

# CHAPTER 1

# INTRODUCTION

Any living being can be a patient, which might incorporate individuals, creatures, pets, and so on. The patients under person classification might incorporate business person, social specialists, lawmakers, Doctors, patients, and so forth. These individuals might occupy in their day by day routine life plan. In the event that they are experiencing any sort of disease/illness, then it's their obligation to take the best possible medicines in legitimate amount at the correct time. On the off chance that the patient is at home then the relatives might recall and reminds patients to take the medicines. In any case, it is unrealistic for the relatives give an update by calling them when the patient individual is out of home/city. For this reason there ought to be some office for the patients, which will remind them about their medicine required some investment. Presently days there is countless phone/advanced mobile phone clients on the planet. The massive number of an assortment of uses accessible in the mobile phone made the lavish life. Mobile phone organizations are giving such a great application to their clients, then the inquiry emerges personality a top priority that why not to utilize those applications when the organization is giving them? Out of those applications, update application in the mobile phone is the most ordinarily utilized applications which are utilized for counteracting to recollect every single little thing. Most outpatient medication mistakes were made when patients purchased endorsed medicines from the distinctive drug stores and utilize them at home without direction. Normal reasons for these blunders include:

- Irregular medicine admissions because of the patient's bustling calendar,
- Complicated admission plans because of the expanding number of medicines taken by the patient,
- Adverse drug responses created by conflicting solutions acquired from various sources,
- Absence of learning about legitimate utilization of medicines (Zao et al., 2010).

Mobile computing frameworks have been progressively received by the healthcare business. Such frameworks ordinarily give more noteworthy comfort and better availability to both patients and healthcare administration suppliers, regularly bringing

about generous cost and time reserve funds. With more individuals owning and utilizing mobile gadgets, more mobile healthcare applications will be grasped by the overall public, particularly those apparent to be helpful and simple to utilize (Zao et al., 201 0). One of the real difficulties confronted by healthcare suppliers is poor medication adherence. This issue influenced both guys and females of all ages. A number of them are not taking their medications as coordinated (Wu et al., 2007). As elderly patients will probably be distressed with incessant diseases, they have to take more doctor prescribed medicines and poor medication adherence would prompt genuine outcomes. Some basic variables influencing medication adherence have been recognized. The patient might be distracted, or he might think that it's hard to deal with various medications (Kocurek, 2009). A conceivable procedure to defeat this issue is to make utilization of pill boxes or update bundling. There are existing gadgets that can give update administrations to medication. The Automated Pill Dispenser by MedMinder (Ashwimi et al., 2013) is a rectangular plate with different compartments for putting away medications for every day over a week. It is outfitted with wireless technology and can be modified to send visual and sound update. This plate is exceptionally helpful in a home situation, yet is generally massive to be conveyed by the client to better places. Since numerous individuals own mobile gadgets these days, a mobile application introduced on a mobile phone can give the update administration without requiring extra cost or gear.

As of late, disease administration has pulled in significant consideration with the fast development of the elderly populace. Numerous specialists trust that omnipresent healthcare (u-healthcare) advancements can diminish the expense of disease administration on the grounds that these innovations make it conceivable to check the status of a patient remotely and ceaselessly. Gadgets, for example, medication updates (or medication distributors) have been created on the premise ofu-healthcare technology. A medication update is a Personal Health Device (PHD) that apportions medications as recommended. Medication adherence, which alludes to the degree or the degree to which a patient takes the right medication at the opportune time, as indicated by a specialist's remedy, has as of late developed as a difficult issue since numerous studies have reported that non-adherence might fundamentally influence the patient, in this manner raising therapeutic expenses. Consequently, medicinal and drug store staff ought to screen the medication adherence of patients. Inferable from these variables, medication adherence requires further

examination. Medication updates can be exceptionally useful in averting medication administering mistakes, including misdosing. These gadgets brief patients to take the recommended medications at the perfect time while furnishing them with the right measurement (Ashwimi et al., 2013). Most medication updates are stand-alone gadgets. Some best in class medication updates have capacities for correspondence with the goal that they can read remote medical staff on the occasion of misdosing. In any case, when the remedies for a patient are adjusted, the new solutions must be gone into the medication update physically, which requires the restorative staff to go to the patient's home. So also, a director can't design new settings for a medication update remotely.

Adherence can be characterized as the degree to which a patient demonstration of understanding to the therapeutic or wellbeing guidance. Adherence is imperative for the achievement of a treatment, particularly on account of unending illnesses. It is connected with lower mortality and can be characteristic of a general solid conduct (sound adherer impact). Patient's non-adherence is a relentless issue that undermines treatment advantages and builds medicinal services costs. In the 2003 who report on medication adherence, it is expressed that around half of patients with perpetual illnesses don't take medications as endorsed (Maglogiannis et al., 2014).

There are a few obstructions to adherence, including worries about the viability or reactions, burden, poor specialist patient relationship and absence of inspiration (West et al., 2012). Adherence can be measured specifically (i.e. Recognition of chemicals in body liquids, direct perception of the patient) or, all the more ordinarily, by implication (i.e. Medication observing, self- reports).

Direct measures are for the most part viewed as more dependable, however, they are additionally expensive, work concentrated and as a rule unrealistic. Medication checking as a rule includes the estimation of what number of pills a patient has brought with precision, yet give no data about the season of admission. Self-reports (e.g. Journals, surveys), albeit subject to predisposition, are an extremely regular and simple to execute technique for the estimation of patient adherence. By, straightforward mediations that are simple for both experts and patients and fused into a day by day practice are the most encouraging methodologies in promoting patient's adherence (Doukas et al., 2012).

As absent mindedness is a standout amongst the most widely recognized obstructions to adherence, a straightforward intercession, as electronic updates can be a viable answer for patients who are unexpectedly non-follower (Vervlvet, 2012). Electronic update frameworks can be a critical component of helping living applications. Numerous clients of such applications have issues recollecting data and essential errands. Also, considering that the essential clients in home consideration technology are generally elderly or individuals with huge tactile weaknesses, multimodality is a fundamental component for update frameworks (McGee-Lemon et al., 2011).

### 1.1 The Aim of the Study

The aim of this study to develop a mobile reminder system that involves the creation of reminders using their Android device, which are stored in a Cloud infrastructure for helping patients to medication adherence.

### 1.2 The Important of the Thesis

All the live long day the quick development of mobile sales and dispersal of mobile services, in spite of intrinsic issues, for example, lack of asset, limited vitality and low availability these issues have been tended to by cloud computing technology (Fernando, 2012). The importance of the thesis is to develop a system based mobile application that helps the patient in medication compliance and also a system that create communication means between doctors and their patients. The system can be used by the patient also give reasons for non-adherence and can be used by the doctor to remind the patient to take his/her medications on correct time.

### 1.3 Limitation of the Study

The limitation of the thesis is as follows:

- The application in this study can only run on the device based on Android platform version 5.0.1.

### 1.4 Overview of the Thesis

Chapter 1 gives details about the general introduction of adherence to medication, the importance of the study, the aim of the study, the limitation of this study and most importantly the breakdown of this study.

Chapter 2 presents the related research work on the adherence medication system.

Chapter 3 introduces the theoretical framework whereby various aspects of the adherence medication system, non-adherence, etc. were discussed.

Chapter 4 talks about the system development and architecture etc.

Chapter 5 the system implantation was discussed in details.

Chapter 6 is about the conclusion of the entire research study and recommendations of the thesis, suggestions, and for future studies.

## CHAPTER2

## RELATED RESEARCH

By point of interest investigation of restorative blunders led by the US Institute of Medicine in 1999 medication mistakes (ME) and unfriendly drug responses (ADR) are the most widely recognized cases among every single therapeutic blunder. These unfavourable drug occasions (ADE) brought about critical tolls as far as patient casualty, money related expenses (counting extra therapeutic costs, wage and profitability misfortunes), and harms to the notoriety and assurance of healthcare experts. The vast majority of these mistakes are nonetheless preventable (Wang et al., 2010). One study discovered 530,000 preventable ADEs among Medicare out-patients every year. In spite of the fact that blunders can happen at each progression of the medication process amid medicine obtainment, remedy, administering and organization, they happen most as often as possible in the solution and organization stages. In the previous decade, progressively across the board utilization of mechanized doctor request section (CPOE), clinical choice emotionally supportive networks (CDSS) and electronic therapeutic records (EMR) alongside best strategies to apportion medicine has wiped out a huge extent (up to 80%) of solution mistakes, which represent half of all medication blunders (Wang et al., 2010). In correlation, little advance has been made in the aversion of organization blunders, which are brought on by despicable and fizzled utilization of endorsed medicine. Therefore, medication organization mistakes have turned into the common reason for ADEs. They represented 25%-40% of all medication mistakes and were the principle purpose behind affirmation of elderly into nursing homes (Zoa and Liu 2010). Out-patient medication organization has been distinguished as the most mistakes inclined methodology in the midst of the whole medication process. The vast majority of these mistakes were made when patients purchased endorsed and over-the-counter (OTC) medicines from various drug stores and utilize them at home without practically no direction. Normal reasons for these blunders include: (1) sporadic medicine in-takes because of the patient's occupied or flighty ways of life, (2) muddled in-take plans because of numerous medicines and measurements taken by the patient, (3) unfriendly drug responses created by un-accommodated remedies acquired from various sources, (4) absence of information about appropriate utilization of medicines, (5) absence of meeting with healthcare suppliers when perplexity emerges and (6) absence of checking components to monitor patient's

medicine in-take. As of late, telemedicine, particularly telemonitoring methods, has been examined as a financially savvy way to deal with control the nature of the consideration (QoC) in the out-patient medication organization (Zoa and Liu 2010). By sending admission suggestions to the patient, delivering the best possible medicine from a medical gadget and recording patient's admission plans, Health Maintenance Organizations (HMO) would like to lessen the expense of administration while enhancing the nature of consideration. The correspondence in the middle of HMOs and patients is set up through wired or wireless Internet associations. In spite of the fact that these endeavors speak to advance in the right heading, the medicine distributors accordingly made are cumbersome, costly and inclined to administering blunders. A helpful option arrangement can be given by introducing a medication update and screen on a brilliant mobile phone and afterward utilizing it alongside a customary mechanical "pill box". Such an answer will be less expensive (barring the caused expense of the advanced cell) and might bring about more profound infiltration into the shopper market (Wang et al., 2010).

Maglogiannis et al. (2014) expressed from their study on "mobile update framework for social affair patient adherence using thing smartwatch and Android gadgets that patients' non-adherence is a typical issue" that fundamentally diminishes the adequacy of medicines and expands mortality and human services costs. Distraction is accounted for as a standard hindrance to adherence. Electronic update frameworks comprise an inexorably utilized kind of intercession, which helps patients that are confronting this issue. Critical necessities in regards to the configuration of such frameworks are multimodality, personalization and simple reconciliation into the patient's day by day life. The objective of their work is to display a multimodal electronic update framework that backings the utilization of brilliant gadgets and uses the use of late presented Pebble smartwatch. Their framework utilizes cloud technology furthermore takes into consideration different sorts of clients with a supporting part in the patient's human services, for example, the patient's specialist and drug specialist. Patient consistence is measured naturally by the strategy for self-reporting.

Tan et al. (2013) displayed an easy to understand mobile application that naturally produces caution signs to remind a client to take medication. Their application can naturally handle a solution of different medications and give a visual update, and a sound

update in the client's picked dialect/vernacular. Furthermore, their application can advance medication adherence among elderly patients.

Ashwini et al. (2013) reported from their study on "an android construct alteration update framework situated in light of OCR utilizing ANN" that the vast majority of times patients might neglect to take the medicines at the legitimate time, according to the predefined in the remedy which might bring about in late recuperation from the disease/illness. So it is important to take appropriate medicines in legitimate amount at the correct time. In their study, they present an Android based application for the patients. Their application will remind their client to take appropriate medicines in legitimate amount at the correct time via consequently setting the updates in the mobile. These updates will be consequently set by the application according to the solution. Furthermore, their update will remind their client, patient that now it's an ideal opportunity to take the medicine.

Stawarz et al. (2014) reported from their perception made on a study on "keep in mind your pill! Outlining successful medication update applications that bolster clients' every day schedules" that in spite of the way that 33% of all instances of inadvertent medication non-adherence are brought about by straightforward carelessness, the dominant part of intercessions disregard this issue. Despite the fact that patients have admittance to smartphone ("applications") intended to offer them some assistance with remembering medication, neither their quality nor viability has been assessed yet. They reported the discoveries of a practical audit of 229 medication update applications and a topical investigation of their 1,012 client surveys. Their examination highlights the hole between the hypothesis and practice: while the writing demonstrates that numerous medication regimens are frequent in nature and the vicinity of every day schedules bolsters recalling, existing applications depend on clock based updates. To address this dissimilarity, they exhibited outline prerequisites for building medication updates that backing the normal part of medication-taking and its individual nature, and show how they could be actualized to move from uninvolved alarms to a more quick witted memory and routine associate.

Park and Lim (2012) proposed a medication update synchronization framework that comprises of medication update operators introduced in medication updates and a medication update director introduced on a medication server. The medication update synchronization framework furnishes a patient with medications as recommended by

restorative staff. What's more, therapeutic staff can remotely send messages to the framework keeping in mind the end goal to change the medication timetables or gadget setup settings implanted in the medication update. Their proposed framework bolsters the OMA (open mobile organization together) DS (information synchronization) convention, which was initially proposed as a DS standard convention that synchronizes information between mobile gadgets and a focal server. In their study, the OMA DS convention is reclassified and stretched out to transmit the patient's medication status information and the gadget setup information.

Dayer et al. (2003) from their study on "smartphone alteration adherences applications: potential advantages to patients and suppliers" that medication nonadherence is a typical, complex, and expensive issue that adds to poor treatment results and expends human services assets. Nonadherence is hard to quantify unequivocally, and mediations to moderate it have been to a great extent unsuccessful. Utilizing smartphone adherence applications speaks to a novel way to deal with enhancing adherence. This promptly accessible technology offers numerous elements that can be intended to help patients and medicinal services suppliers enhance medication-taking conduct. Right now accessible applications were distinguished from the three principle smartphone Oss (Apple, Android, and Blackberry). Furthermore, alluring elements for adherence applications were recognized and positioned by saw significance to client attractive quality utilizing a three-point rating framework: 1, unassuming; 2, moderate; or 3, high. They chip away at the 10 most elevated appraised applications, which were introduced and subjected to client testing to survey application characteristics utilizing a standard medication regimen. 160 adherence applications were distinguished and positioned. These applications were most predominant for the Android OS. Adherence applications with cutting edge usefulness were more pervasive on the Apple iPhone OS. Among all applications, MyMedSchedule, MyMeds, and RxmindMe evaluated the most noteworthy as a result of their essential medication update highlights combined with their upgraded levels of usefulness. Regardless of being untested, medication applications speak to a conceivable procedure that drug specialists can prescribe to nonadherent patients and consolidate into their practice.

Brorsen et al. (2014) depicted a setting mindful pervasive quiet medication update framework. Their framework goes for enhancing the anticoagulant treated patient's

medication adherence in light of setting mindfulness. By utilizing propelled sensor technology to enlist the client coıınection, the framework reminds the patient to take the medication auspicious. They tried the framework model and was likewise assessed by a patient, and was accounted for valuable. The setting mindful updates additionally improved the patient's adherence to medication consumption.

Zao and Liu (201 0) expressed that out-patient medication organization has been distinguished as the most blunder inclined methodology in cutting edge healthcare. Under or overdoses because of unpredictable admissions, drug-drug or drug-sustenance cooperations brought on by un-accommodated solutions and the nonappearance of admission authorization and checking instruments have created medication mistakes to end up the normal instances of every single medicinal blunder. Most medication organization mistakes were made when patients purchased endorsed and over-the-counter medicines from a few drug stores and utilize them at home without practically zero direction. Elderly or chronically sick patients are especially defenceless to these errors. In their study, they present Wedjat, an advanced mobile phone application intended to offer patients some assistance with avoiding these missteps. Wedjat can remind its clients to take the right medicines on time and record the admission plans for later audit by healthcare experts. Wedjat has two recognized components: (1) it can alarm the patients about potential drug-drug/drug-sustenance cooperations and arrangement an appropriate admission timetable to stay away from these collaborations; (2) it can overhaul the admission plan consequently when a measurement was missed. In both cases, the product dependably tries to deliver the easiest plan with minimal number of admissions. Wedjat is furnished with easy to understand interface to help its clients to perceive the best possible medicines and get the right directions of taking these drugs. It can keep up the medicine admission records on board, synchronize them with a database on a host machine or transfer them onto a Personal Heath Record (PHR) framework. A proof-of-idea model of Wedjat has been actualized on the Window Mobile stage and will be relocated onto Android for Google Phones. Their concentrate likewise presents the framework idea and outline standards of Wedjat with accentuation on its medication plaıınıng calculations and the secluded execution of a mobile computing application.

Zao et al. (2010) talked about the methodology of Wedjat - Smart Phone Application which depends on to help patients to maintain a strategic distance from medication organization blunders which are specified previously.

Wedjat can perform three essential capacities:

- Issue medicine admission updates
- Provide medicine distinguishing proof and admission headings
- Maintain medicine consumption records

So also, Prasad B examined the methodology of Medicine Reminder Pro which depends on reminding medicine plans. This free application underpins up to 15 updates. The client can choose them in either rehashing or non-rehashing alert examples. Any hourly time interim between cautions can be chosen, beginning from the base of 60 minutes. At the planned time, the application will create a warning with an alert, vibration or LED sign (Ashwini et al., 2013).

- Additionally MED Minder methodology by David Garland of Garland Systems, which, according to their idiom, is without simple, full included pill and medicine scheduler and medication update application.
- The client needs to include the update physically about taking the measurements, i.e. 2 times or 3 times in a day.
- The client needs to physically select the week days about the update.
- Existing frameworks are not giving any office about end of medicines.
- They are additionally not giving any sort of office about the first remedy.
- There is nothing happening consequently. Everything necessities to do manually.

# CHAPTER3
# THEORETICAL FRAMEWORK

## 3.1 Cell Phones

Cell phones are Internet-arranged multipurpose devices that allow reliable access to correspondence and information and perform various endeavors. Most assignments are performed by particular (applications) that customers can without a lot of a stretch download and use to help them in a combination of limits. Using a cell phone application is a novel approach to manage improved adherence and patient behavior; it is constantly open, incorporates and teaches the patient, and gives a document to patient-and solution specific information (Delpier et al., 2012). A cell phone drug adherence-oriented application (adherence applications) can cement most of the customer's prescription specific information and in this way to give a more streamlined strategy to instruct the individual about his/her infection or thought. Adherence applications can be downloaded for all intents and purposes no cost, and their preferences may be recognized by anyone taking doctor prescribed solutions. Regardless, these applications may exhibit most valuable for patients with complex prescription regimens or for watchmen of others or relatives. The creating pervasiveness of cell phones in the United States and their enduring, straightforward accessibility make adherence applications addressing various in light of the way that they cost little and can give customer specific information (Delpier et al., 2012).

The quantity of applications went to helping the client in sorting out and taking their medications is expanding over the overwhelming smartphone stages. Among the starting now advanced adherence applications, highlights join redesigns that can be set for usage and refills, estimations that can be logged, data logs that can be gotten to by patients or exchanged to care, suppliers, and pharmaceutical information (e.g., measurements, opposing effects, toxicities, particular supplier takes note of), all of which can be promptly open with the touch of a finger. Likewise, these applications might likewise incorporate logbook based caution updates with the particular dose or usefulness that coordinates medication records with particular drug data or joins drug store and essential consideration contact data or incorporates professionally prescribed drug rebate cards. Endeavours are under approach to coordinate smartphones with wellbeing checking gadgets that transmit

the yield information straightforwardly to patients or doctors. Writing on the clinical utility of the smartphone and utilization of applications in ranges of wellbeing, health (e.g., weight administration) is developing, yet exact examinations of patient utilization of the smartphones with applications as a guide to encourage adherence are missing (Delpier et al., 2012; Kharraz et al., 2012; Lee et al., 201 I; Wohlers et al., 2009).

### 3.1.1 Mobile Reminders

By most recent measurements, 92% of UK grown-ups own a cell phone and 39% own a smartphone (Stawarz et al., 2014). The universality of mobile gadgets, joined with their own temperament (Ofcom, 2012) and their usefulness, for example, content informing, applications, or Internet access, make cellphones a compelling stage for conveying wellbeing intercessions (Klasnja and Prat, 2012; Yun and Arriaga, 2013). Among cellphone-based intercessions went for supporting recalling, instant message updates are the most broadly utilized.

### 3.1.2 Messages

Instant texts have been used as redesigns as a part of a couple wellbeing interventions (e.g. Hou et al., 2010; laird, 2012; Hou et al., 2010). Case in point, Hou et al. (2010) surveyed the impact of SMS reports on adherence to oral contraception. For three months, on end picked before the trial, 82 individuals got a step by step SMS recommendation to take the Pill. The results showed that paying little mind to the regular upgrades, the intervention did not improve adherence stood out from the control group. Plus, women who completed the trial with a splendid adherence record had felt toward the begin of the study that they would not require SMS redesigns, which recommends that they either viably used their own upgrades or relied on upon a calendar. The concentrate moreover exhibits that texts are not adequately versatile: they are fundamental clock based upgrades that require brief thought. As each SMS was sent just once, women were not prepared to put off the upgrade if they couldn't take the Pill in a flash, which suggests that cell phone applications with redesigns that can be "refreshed" might be more qualified as memories reinforce mechanical assembly.

### 3.1.3 Smartphone Applications

Cell phone customers have basic access to a substantial number of wellbeing related versatile applications (Laird, 2012). In spite of the way that few studies of wellbeing applications have been driven, pharmaceutical redesigns have not been assessed to date. Case in point, an overview of the primary 500 restorative applications open in Italian application stores drove in 2012 (Obiodu and Obiodu, 2012) recognizes 58 "wellbeing diaries", which fuses "medicine arranging applications". In any case, no extra information about these applications is given. Another review from 2013 (Dayer et al., 2013) delineates more than 160 medicine adherence applications open for different sorts of cell phones, and disregarding the way that pharmaceutical redesigns were consolidated, the accentuation was on deliberate non-adherence and evaluating the applications from a medication authority's perspective. Despite the way that the practicality of the applications had not been formally surveyed at the time and their relevance to customer's needs had not been assessed, makers contemplated that these applications can help with solution regimens. Rather than evaluating existing applications, a couple of experts have proposed their own answers. Case in point, Silva et al. (2009) arranged a solution upgrade application that allowed customers to enter diverse pharmaceuticals, showed up due times and taking rules, and highlighted past due estimations. The application did not shift much from business applications, and since its accentuation was on redesigns, routine support was not available. In any case, the makers made a course of action of helpful necessities that address different openness issues, joining motorized redesigns with different modalities (visual and sound-related alerts) and the snooze decision to expect missing measurements, which could be considered while laying out an overhaul system that takes plans into the record. De Oliveira et al. (2010) took a substitute procedure: to people make plans, they sketched out an application that bolstered steady use by adding a forceful part to prescription taking. Customers were allowed adherence scores, which were then granted to their partners and appeared on a pioneer board. The redirection did not give redesigns and customers expected to review without any other individual's data, disregarding the way that the consideration was on winning and taking the medicine at a specific time rather than fundamentally taking it reliably. Consequently, timetables were not satisfactorily all around described and customers required their own specific clock based overhauls.

#### 3.1.2.1 Effectiveness of cell phone adherence applications

Despite the way that cell phone applications can upgrade the ampleness and reduce the costs of ordinary prescription adherence interventions, their reasonability is at this moment untested. Data display that electronic portable contraptions using upgrade systems through standard strategy for telecom, like Short Message Service (SMS) content educating, improve adherence and direct and can be useful in measuring adherence in the short term (Vervloet et al., 2012). Specialists found that sending photographs of prescription cases through cellular telephones before ingestion gave more exact time measures of adherence (Galloway et al., 2011). One study found that youngsters with asthma who used a specific structure to make and timetable individual text redesigns gave the system high examinations for sufficiency, ease of use, and accommodation; in any case, their asthma control was similar to benchmark (Britto et al., 2012). In a study using a thorough, Web-based guideline structure with Internet and PDA access to control blood glucose levels in patients with diabetes, the repeat of getting to the Emod (electronic Management of Diabetes) system through a telephone was basically related to the change in glycosylated hemoglobin levels (Noh et al., 2010). Regardless of the way that an orderly study of Internet-based adherence interventions found promising results, it furthermore found that a couple concentrates on required quality estimations of adherence (Linn et al., 2011). Distinctive examinations of the use of cell phones in the clinical setting have been performed (Wu et al., 2011), yet focuses precisely testing cell phone applications to upgrade adherence are lacking.

### 3.1.3 Reminder Apps Types

As prescription redesign applications gave convenience of varying multifaceted nature, in light of their components they were assembled into three essential classifications (Stawarz et al., 2014):

- Simple medication reminders (SMR): Applications offering essential capacities supporting forthcoming memory, for example, alarms, versatile booking, adaptable prepared sorts and sounds, rest, etc.
- Advanced medication reminders (AMR): Applications giving choices that backing both imminent and review memory, for example, time zone support, overdosing

security, solution pictures, client notes, late measurements taking after, medicine log, brilliant hushing, et cetera.

- Medication medication applications (MMA): AMR applications that additionally administer wellbeing and drug regimens. As some of them backing different client accounts, they can be further part into individual prescription organization applications and family drug organization applications.

They allow clients to store their wellbeing information, specialist's contact points of interest, give arrangement updates, and so on.

### 3.2 **Medication Non-adherence**

Medication non-adherence decreases the adequacy of a treatment and forces a cash related weight on therapeutic administrations frameworks (Stawarz et al., 2014), in the USA alone, the evaluated expense of non-adherence comes to $100 billion consistently, including the expense of 10% of clinic and 23% of nursing home confirmations (Vermeire et al., 2001). Most of adherence intercessions made to address this issue concentrate on purposeful nonadherence and their point is to show people and change their states of mind and convictions (Stawarz et al., 2014). Nevertheless, even impelled people can disregard: absent mindedness represents 30% of instances of surprising non-adherence (Unni and Farris, 2011) and around one million undesirable pregnancies consistently are the aftereffect of nonadherence (Stawarz et al., 2014) and eccentric utilization of the prophylactic pill ("the Pill"), with neglect as one of the essential driver (Smith and Oakley, 2010). Be that as it may, then, mediations explicitly tending to absent mindedness, particularly for assurance treatments, for example, oral contraception, are few and far between, and in addition tend to concentrate on updates advised people to take their drug at a predetermined time (Vervolet et al., 2012). This emphasis on timed cautions dismisses the way that time-based undertakings are more difficult to remember than assignments related to routine activities (Stawarz et al., 2014) and various drug regimens are progressing errands that could be effortlessly joined into a step by step plan, which in itself additionally underpins reviewing. The standard backing could be given by innovation. With the expanding reputation of cell phones, people now have passage to a great many wellbeing related ("applications") (Laird, 2012) that could offer them some help with recalling their medicine. Notwithstanding the way that starting late a couple application surveys have been distributed (e.g. Dayer et al., 2013; Obiodu and Obiodu, 2012; O'Neil

and Brady, 2012; Rosser and Eccleston, 2011), to date, prescription overhaul applications have not been examined or evaluated by academic specialists, and thus their adequacy or the extent to which they address clients issues are not known.

### 3.3 **Medication Adherence/Compliance**

Remembering to take medicine is a forthcoming memory undertaking and in that capacity it depends on an arrangement of scholarly procedures in charge of completing activities sooner or later on (Stawarz et al., 2014). There are two guideline sorts of imminent memory undertakings: time-based errands that ought to be done at a predefined time (e.g. Take medicine at 9:00) or after a set time span has passed (e.g. Take anti-microbials at standard interims); and event based undertakings, where the errand is associated with a current event and nature in which it happens, e.g. carrying pharmaceutical with breakfast. Dependent upon individual circumstances, a drug regimen can be named both these assignments. All imminent memory errands rely on upon prompts, which can be internal (e.g. Considerations), external (updates, notes, et cetera.) or consolidated with an event that triggers the assignment ("conjunction updates") (Stawarz et al., 2014). Outside and conjunction updates are the best as they give more pieces of information (Henry et al., 2012). Therefore, event based assignments bolster memory more satisfactorily than time-based undertakings: they are less demanding to recall and the vicinity of a typical aides lead and gives more applicable signals, expanding the adherence to a helpful treatment and supporting penchant improvement (Stawarz et al., 2014). Propensities and Routines Habits are an effect on an unfaltering learning of examples of behavior and relationship between the errand or its elements and the earth (e.g. Region), particularly when activities are reliably and from time to time performed in a succession (Stawarz et al., 2014). To be changed into a penchant, an undertaking ought to be basic (Fogg, 2015; Lally and Gardner, 2011), be connected with a current routine errand (Fogg, 2015) and give positive fortress (Fogg, 2015; Lally and Gardner, 2011). It likewise should be sufficiently repeated times to end up a typical behavior (Lally et al., 2010). As prescriptions much of the time ought to be taken routinely and within a particular time allotment, various regimens are genuine progressing undertakings - patients make sense of how to relate their pharmaceuticals with a particular time of day, region or event. By Medication Adherence Model, such composed behavior is an essential bit of prescription taking, as it is customized, exceptional for each individual and mirrors their way of life and step by step exercises (Stawarz et al., 2014).

Subsequently, timing (e.g. Breakfast time) and the territory (e.g. Kitchen) are key components of a calendar, and make it all the more basically, huge and strong (Johnson, 2002). Case in point, the showing of eating in the kitchen at first serves as a sign to take the drug and, with time, changes the behavior into a continuous action. Regardless, while schedules can make dull assignments less demanding through the development of modified activities, they can likewise be hazardous when the undertaking requires thought (Stawarz et al., 2014). The automaticity of a behavior joined with interruptions to the typical increment in the likelihood of exclusion and emphasis mistakes (Stawarz et al., 2014), which ought to be considered when planning an innovation that uses schedules.

### 3.3.1. Epidemiology of Non-adherence

By International Society for Pharmacoeconomics and Outcome Research (ISPOR), adherence is "the extent to which a patient goes about according to the endorsed interval, and measurements of a dosing regimen" (Stawarz et al., 2014). Pharmaceutical non-adherence can impact tolerant wellbeing antagonistically, conversely influence a patient's association with his/her thought supplier, skew aftereffects of clinical treatment trials, and expansion wellbeing asset utilization (Stawarz et al., 2014). Prescription non-adherence remains a regular human administration issue. Poor adherence causes around 33% to 69% of prescription related hospitalizations and records for $100 billion in yearly social protection costs (Stawarz et al., 2014). Regardless of infection, pharmaceutical many-sided nature, or how adherence is measured, the ordinary adherence rate to interminable prescription treatment is around half (Stawarz et al., 2014). Adherence checking ought to be performed routinely to guarantee therapeutic sufficiency, avoid superfluous measurement and regimen changes, contain human administrations costs, and in particular cases, keep imperviousness to treatment from rising (Garfield et al., 2011).

### 3.3.2 Adherence Measurement

Techniques to gauge adherence, including quiet self-reports, pill numbers, refill rates, regular watching, and electronic checking, have confinements and are recently go-between measures (Garfield et al., 2011). Quiet self-reports rely on upon memory and are slanted to errors and audit predisposition (Stawarz et al., 2014). Pill checks are hazardous if patients disregard to return containers or dump pills before the number (Stawarz et al., 2014). Natural watching (e.g., inspecting blood, pee) is unfeasible, obtrusive, or meddlesome and

does not gauge adherence unless the time and dosage managed before examining are checked. Refill rates or electronic watching can't make sense of if patients truly take the medicine. In spite of the way that the procedure of top clearing does not as a matter of course reflect dosage ingestion, medicine electronic checking frameworks are helpful for figuring adherence rates for measurement taking and measurements timing and routinely are seen as the best technique to gauge adherence (Rolnick et al., 2011). In any case, notwithstanding their restrictions, these strategies are tasteful for chronicling non-adherence, yet when all is said in done, simply self-report techniques can recognize among the different sorts of non-adherence depicted underneath.

### 3.3.3. Non-adherence Types

The reason for prescription non-adherence differs among patients and is broadly requested as surprising or consider. Incidental non-adherence includes wanting to take a solution as trained, however fail to do all things considered for no good reason (e.g., absent mindedness, thoughtlessness). Coincidental non-adherence is affected by patient qualities, treatment variables, and patient-provider issues (Stawarz et al., 2014). Interestingly, intentional non-adherence includes settling on a contemplated choice not to take a prescription as taught in view of observations, emotions, or convictions (Daleboudt et al., 2011). Planned non-adherence mirrors a goal choice creation process by the patient whereby the advantages of treatment are weighed against any unfriendly impacts of the treatment (Stawarz et al., 2014). Widely depicting non-adherence may misrepresent the complexities included with non-adherence; in any case, it is practical and shows that directing non-adherence requires different intercessions (Garfield et al., 2011).

### 3.3.4 Adherence Behavioral Models

Most medicine adherence models depend on a few social observation models, including the wellbeing conviction model, social subjective theory, and theories of orchestrating behavior (Stawarz et al., 2014). These models are comparable, and all expect that conviction made by the individual shape how they disentangle the information and encounters and finally affect their behavior (Stawarz et al., 2014). As requirements be, wellbeing conduct (e.g., prescription taking) results from adjusted choices taking into account all available information (Stawarz et al., 2014).

### 3.3.5 Medication Adherence Methods of Enhancement

Various strategies to upgrade pharmaceutical adherence have been concentrated on. Most strategies try to change using so as to understand behavior updates, advising, fortress, guideline, measurement disentanglement, or a mix of these techniques (Graves et al., 2010). All things considered, adherence intercessions are organized as behavioral, informational, or legitimate taking into account changing the patient's surroundings or motivators, giving more information, or lifting boundaries connected with prescription capriciousness and correspondence with thought suppliers (Graves et al., 2010).

#### 3.3.5.1. Conventional Reminders

Normally, pill update frameworks (e.g., week by week pill boxes, packaged logbooks, unit-of-utilization packaging), are valuable adherence helps, particularly when non-adherence is coincidental (Rolnick et al., 2011; Harbig et al., 2012). Current standard overhaul frameworks unimportantly incorporate the patient in the self-pharmaceutical process and don't give them access to their adherence data or other informational information. Notwithstanding the way that pill upgrade frameworks have been tried and appeared to be helpful over various prescriptions, these frameworks are bulky for complex regimens and just inactively reminding patients to take their pharmaceutical (Mahtani et al., 2011; Zedler et al., 2011). Electronic frameworks proactively pass on updates by phone, pager, and varying media gadgets, however may be preposterous for boundless use and more useful if solidified with choice behavioral techniques (Fenerty et al., 2012).

### 3.3.6 Other Behavioral Interventions and Counseling

Most studies on upgrading adherence incorporate behavioral intercessions (Bain-Brickley et al., 2011). Data recommend that patient direction is one of the best techniques for upgrading adherence, particularly for those all the while regulating more than six meds. Dependent upon the sort of nonadherence and patient qualities, utilizing a blend of uniquely crafted mediations, for example, tolerant preparing, understanding self-checking of specific thought, and boosts to take pharmaceuticals have the best potential for improving adherence (Graves et al., 201 0).

### 3.4 Mobile Operating Systems

A champion amongst the most by and large utilized innovations today is versatile innovation. It incorporates a few or we can say all types of reduced innovation, for example, tablets, palmtops, cellular telephones, individual mechanized collaborators, remote card portion terminals, overall situating frameworks. This innovation is in a general sense expanding far and wide regulated. This can be unmistakably found in our regular life as a poor man additionally either have a cell telephone or has admittance to it. It has changed the technique for cooperating. Already, people use to go to banks or workplaces to do their assignment yet now they can without much of a stretch do it from a cellular telephone. It can be seen that in the recent years the remote advancements were significantly made. Nearby the exponential change in execution and breaking point of remote correspondences frameworks, the information can be effectively gotten to utilizing cell phones. Remembering the deciding objective to upgrade their framework and taking off data scope, the versatile systems is spending an immense whole. The constant advancement in versatile innovation is influencing everyone's life. The clients are getting benefitted from the advances in versatile innovation (Sharma et al., 2013). This is clearly noticeable in our ordinary life. Already, remembering the final objective to mail basic records one needs to pass on it from approach to portal yet with the progress in versatile innovation one can undoubtedly send it in a few minutes as delicate copy. As a haven, the utilization of advanced mobile phones and tablets has changed correspondences, energy. The advancement in portable innovation is affecting different distinctive fields likewise like it is accepting a fundamental part in social protection frameworks. As a delineation, if a man claims a business, then he is permitted to grow his business rather than limiting it to a particular district. This can be seen subsequent to the earlier year that with the expanding number of years, three eras of portable are likewise expanding. The period of a cellular telephone is spoken to by 'G'. From 1946 to 1980, 0G i.e. the zero time won. This included early cellular telephones which were uncommonly costly and it must be utilized as a part of autos, trucks and portfolios. It had a voice call highlight in a manner of speaking. After 0G forefront came which is 1G i.e. to start with period. In this period cellular telephones were straightforward gadgets which work on AMPS/Datatec innovation. Its elements were voice calls with confined data which was to some degree higher than the past period. As the time passed the accompanying mechanized period

showed up which is the 2G i.e. the second period mobileular framework. Its ~mponents were fairly enhanced than the past eras. It had voice, SMS and circuit exchang~p~<q,'?- highlights. The advances which won in the midst of this period were GSM, iDEN, EDGE, GPRS, CDMA, TDMA and HSCSD. Out of the above advancements some fit in with the 2.5G standard group. With a particular final objective to display new components and advancements, the front line was introduced i.e. 3G. It had prevalent components like broadband data, voice and spilling video, however this innovation was not totally realized (Sharma et al., 2013). It came into light from 2004 which included advances like W-CDMA, lXev-DO. To incorporate some new elements in the past form of the period, 4G was exhibited. This time had quicker broadband for data and visual driven information which is fit for transmitting data at 1 OOmbps while moving and 1 Gbs while stopping.

### 3.4.1 Android

This is a product stage and working framework for cell phones which depends on Linux piece and is delivered by Google yet later on by Open Handset Alliance (OHA). Its neighborhood tongue is Java, which is the formally upheld lingo. This application can be created in various dialects additionally yet later on it is aggregated to ARM neighborhood code. This Operating System is utilized as a part of Samsung, HTC mobiles.

### 3.4.2 Android advantages

**Multitasking:** Android telephones can run various applications, it implies you can skim, Facebook while listened to the melody.

**Simplicity of Notification:** Any SMS, Email, or even the most recent articles from a RSS Reader, there will dependably be a notice on the Home Screen Android telephone, don't miss the LED marker is squinting, so you won't miss a solitary SMS, Email or even Miscall.

**Simple access to a huge number of uses by method for the Google Android App Market:** When you need to introduce applications or amusements, through Google's Android App Market, Agan can download applications to no end. There are various a huge number of uses and diversions that are readied for download on Android telephones you.

**Telephone alternatives are assorted:** Talk Android telephone, it will feel "unmistakable" than the IOS, if the IOS is compelled to the iPhone from Apple, then Android is open on

cellular telephones from different producers, from Sony Ericsson, Motorola, HTC to Samsung. Moreover, every handset producer additionally shows an Android telephone in the style of each, for example, Motorola with its Motoblur, Sony Ericsson with its Timescape. So you can straightforwardly pick the Android telephone according to the "brand" top decision.

**Can introduce a changed ROM:** Not fulfilled by the standard point of view of Android, don't push there are various custom ROM that can be utilized as a part of your cellular telephones Android.

**Contraption:** Totally right, with the gadgets on the home screen, you can without much of a stretch get to a variety of settings quickly and effortlessly.

**Google Maniac:** If you are a solid client of Google administrations running from Gmail to Google Reader Android telephone has joined with Google administrations, so you can quickly check email from Gmail.

## CHAPTER4

## SYSTEM DEVELOPMENT

The system architecture is illustrated in Figure 4.1 that mainly divided into two sections:

- Server side (Cloud)
- Client side (Mobile device)

The system is part of the online system. Therefore, the application needs the internet to perform some of the tasks in the cloud (client) such as Login and doctor's actions. The mobile devices connect to the internet via Wi-Fi or GSM services. In the server part parse.com is used which is a platform for cloud computing services. It also has the cloud storage for storing all the data. Although, some of the models in the application do not need access to the internet and just work on the mobile device such as medicine, alarm, etc. Figure 4.1 shows the architectural design of the developed system and the user interface between the patient and the doctor.

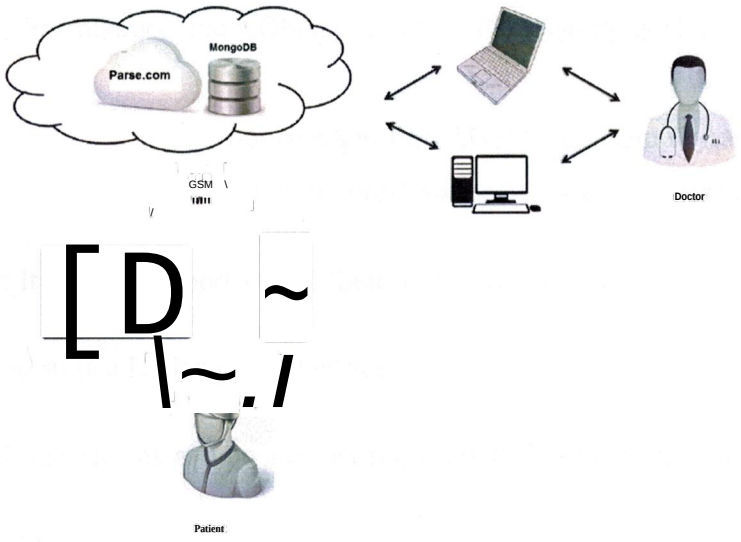



**Figure 4.1:** System architect

### 4.1 System Technology

In this study a set of technologies is used which offers the ability for a patient on drug/medication reminder.

***Mobile technology:*** The system mainly based on a mobile device. Because the mobile device characteristics like available in the mobility to the user, packet size, access to the internet, easy to use (Myung et al., 2015).

***Parse.com Platform:*** This platform provides a supplementary and free library file, which is (JAR) file. It also performs the cloud computing works. The mentioned library is very easy for developers for using it Figure 4.2 shows the screenshot of parse.com.

**Parse.com features:**

1- NOSQL: Parse.com does not need SQL commands for performing database functions.

As shown in the following code:

```
ParseQuery<Parseübject> query= ParseQuery.getQuery("Patient");

query.whereEqualTo("User_Name", par);
query.whereEqualTo("Password", parl );
```

2- NO_SERVER: It lets developers create their apps without a server.

3- BaaS: The platform is a backend as a service.

4- It allows I million requests and pushes per month with 20-burst limit in a second.

5- Social integration.

6- Parse.com using the Google Cloud Message (GCM) library to push notifications to (iOS, OS X, Android and Windows).

7- Web hosting.

8- Supports a number of different platforms.

9-Parse.com can also work offline.

10- Storage on Parse.com is free.

The Parse platform has Core part which stores and manipulates tables in the database. Figure 4.2 shows the database part of Parse.com platform which stores the patients.

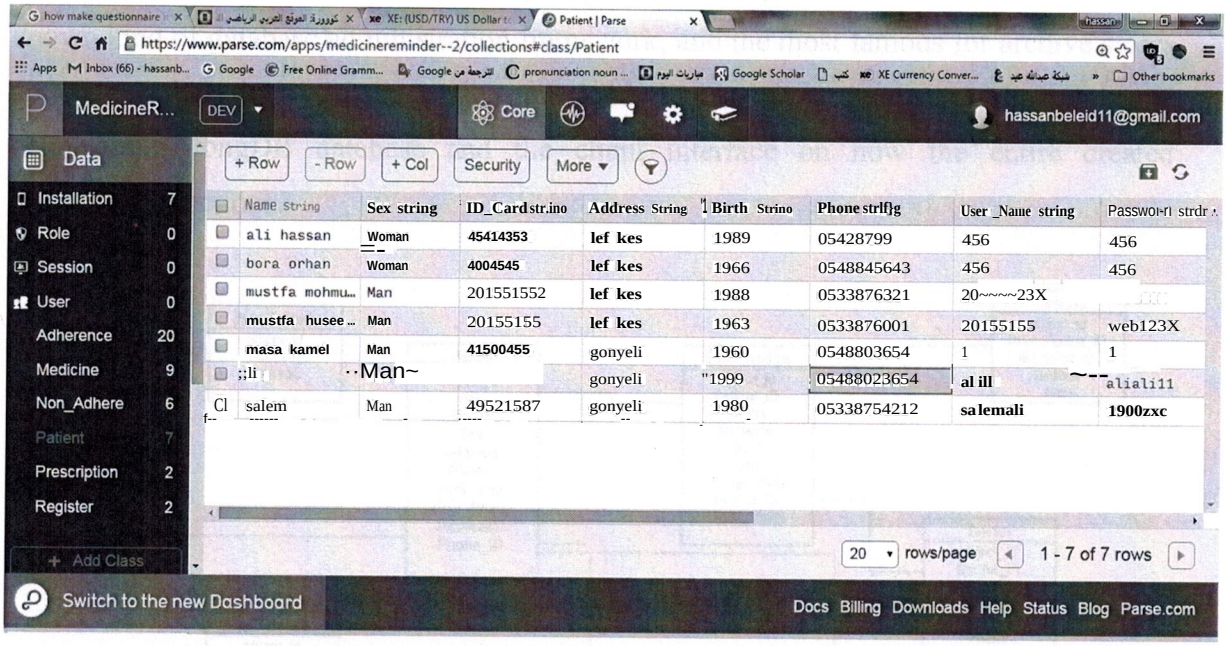


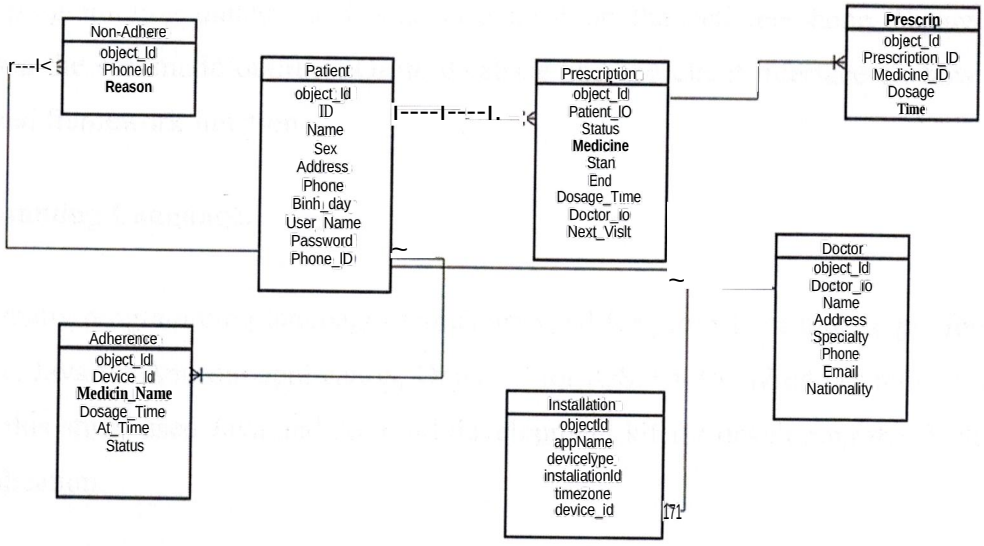

**Figure 4.2:** Screenshot of Parse.com platform

### 4.1.1. Databases

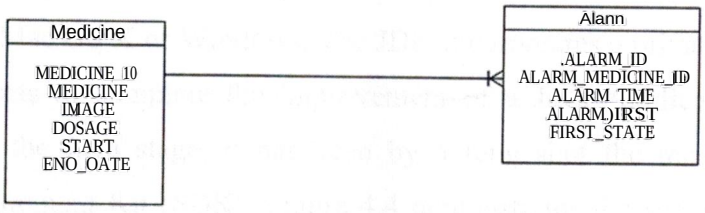
A database is an accumulation of data that is sorted out with the goal that it can without much of a stretch be gotten to, oversaw, and overhauled. In one perspective, databases can be arranged by of substance: Bibliographic, full-message, numeric, and pictures. Databases utilized for this study are as per the following:

- **MongoDB:** It a cross-stage record situated database. Named a NoSQL database, MongoDB shuns the conventional table-based social database structure for JSON-such as archives with element patterns (MongoDB calls the arrangement BSON), making the joining of information in specific sorts of uses less demanding and quicker. Discharged under a mix of the GNU Affero General Public License and the Apache License, MongoDB is free and open-source programming.

Initially created by the product organization MongoDB Inc. in October 2007 as a part of an arranged stage as an administration, item, the organization moved to an open source advancement model in 2009, with MongoDB offering business support and different administrations (Banker, 2011). From that point forward, MongoDB has been received as backend programming by various real sites and administrations, including Craigslist, eBay and Foursquare among others. Starting July 2015, MongoDB is the fourth most well-known kind of database administration framework, and the most famous for archive stores and it was introduced in the parse.com cloud. Figure (a) demonstrates the schematic delineation MongDB database and the client interface on how the entire created framework functions.




**(a)** Schematic illustration MongDB database




**(b)** Schematic illustration SQLite database

**Figure 4.3:** Illustration MongDB and SQLite databases

- **SQLite:** It is a social database administration framework contained in a C programming library. As opposed to numerous other database administration frameworks, SQLite is not a client-server database motor. Maybe, it is installed into the end program. SQLite is ACID-agreeable and executes the majority of the SQL standard, utilizing a powerfully and feebly wrote SQL punctuation that does not ensure the space uprightness (Owen, 2006).

SQLite is a prominent decision as implanted database programming for nearby/customer stockpiling in application programming, for example, web programs. It is apparently the most broadly sent database motor, as it is utilized today by a few far reaching programs, working frameworks, and implanted, among others (Owen, 2006). SQLite has ties to numerous programming dialects and was introduced on the cell telephone. Figure (b) demonstrates the schematic outline SQLite database and the client interface on how the entire created framework functions.

### 4.2 Programming Language:

There are many programming languages which are used for projects of mobile platforms, for example, Java for Android application, Object C for iOS, C# for Windows mobile, etc. Therefore, this study used Java and Android development kit for developing the Android mobile application.

#### 4.2.1. Java Development Kits

The Java Development Kit (JDK) is an execution of both of the Java SE, Java EE or Java ME stages discharged by Oracle Corporation as a paired item went for Java designers on Solaris, Linux, Mac OS X or Windows. The JDK incorporates a private JVM and a couple of different assets to complete the improvement of a Java Application. Following the presentation of the Java stage, it has been by a long shot the most generally utilized Software Development Kit (SDK). Figure 4.4 demonstrates the screenshot of JDK amid the coding of the application.

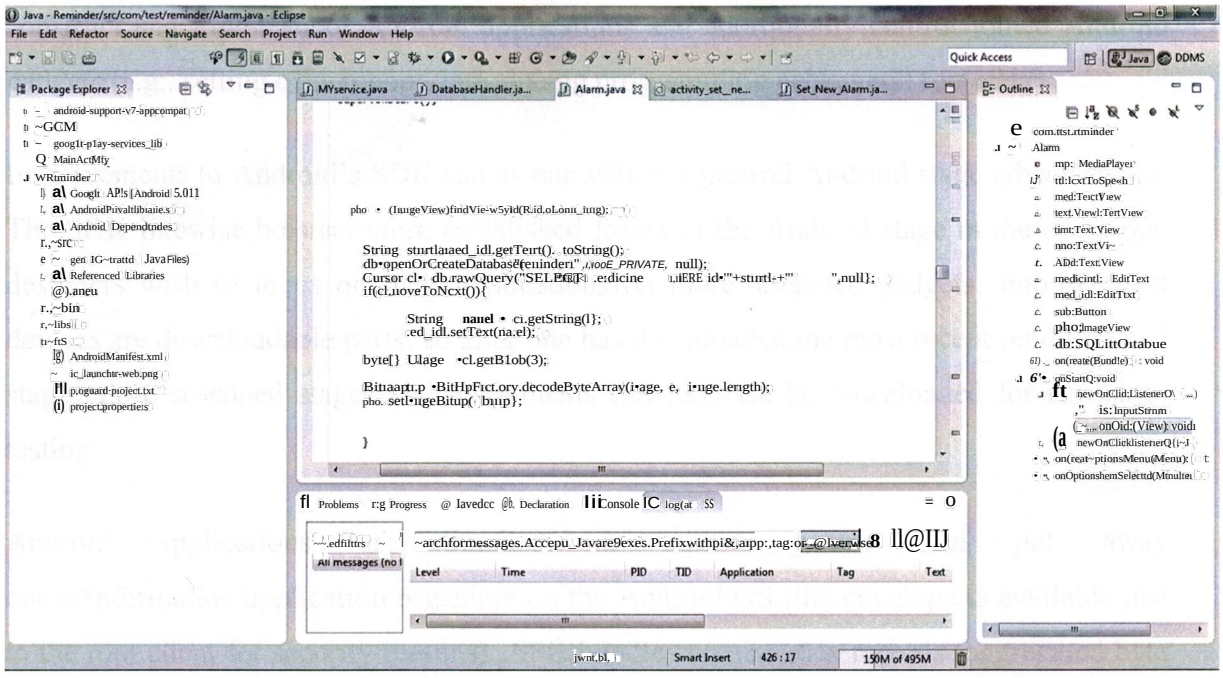



Figure 4.4: Screenshot of JDK

### 4.2.2. Android Development Kits

The Android programming improvement unit (SDK) (Figure 4.5) incorporates a far reaching set of advancement apparatuses. These incorporate a debugger, libraries, a handset emulator taking into account QEMU, documentation, test code, and instructional exercises. As of now upheld advancement stages incorporate PCs running Linux (any present day desktop Linux appropriation), Mac OS X 10.5.8 or later, and Windows XP or later. As of March 2015, the SDK is not accessible on Android itself, but rather the product improvement is conceivable by utilizing particular Android applications.

Until around the end of 2014, the formally upheld incorporated advancement environment (IDE) was Eclipse utilizing the Android Development Tools (ADT) Plugin, however IntelliJ IDEA IDE (all versions) completely underpins Android improvement out of the container, and NetBeans IDE likewise bolsters Android improvement by means of a module. Starting 2015, Android Studio, made by Google and controlled by IntelliJ, is the authority IDE; notwithstanding, engineers are allowed to utilize others. Furthermore, designers might utilize any content manager to alter Java and XML records, then utilize order line instruments (Java Development Kit and Apache Ant are required) to make,

construct and troubleshoot Android applications and additionally control joined Android gadgets (e.g., setting off a reboot, introducing programming package(s) remotely).

Improvements to Android's SDK run as one with the general Android stage advancement. The SDK likewise bolsters more established forms of the Android stage in the event that designers wish to focus on their applications on more seasoned gadgets. Improvement devices are downloadable parts, so after one has downloaded the most recent rendition and stage, more seasoned stages and instruments can likewise be downloaded for similarity testing.

Android applications are bundled in .apk organize and put away under/information/application organizer on the Android OS (the envelope is available just to the root client for security reasons). APK bundle contains .dex records (aggregated byte code documents called Dalvik executables), asset records, and so on.

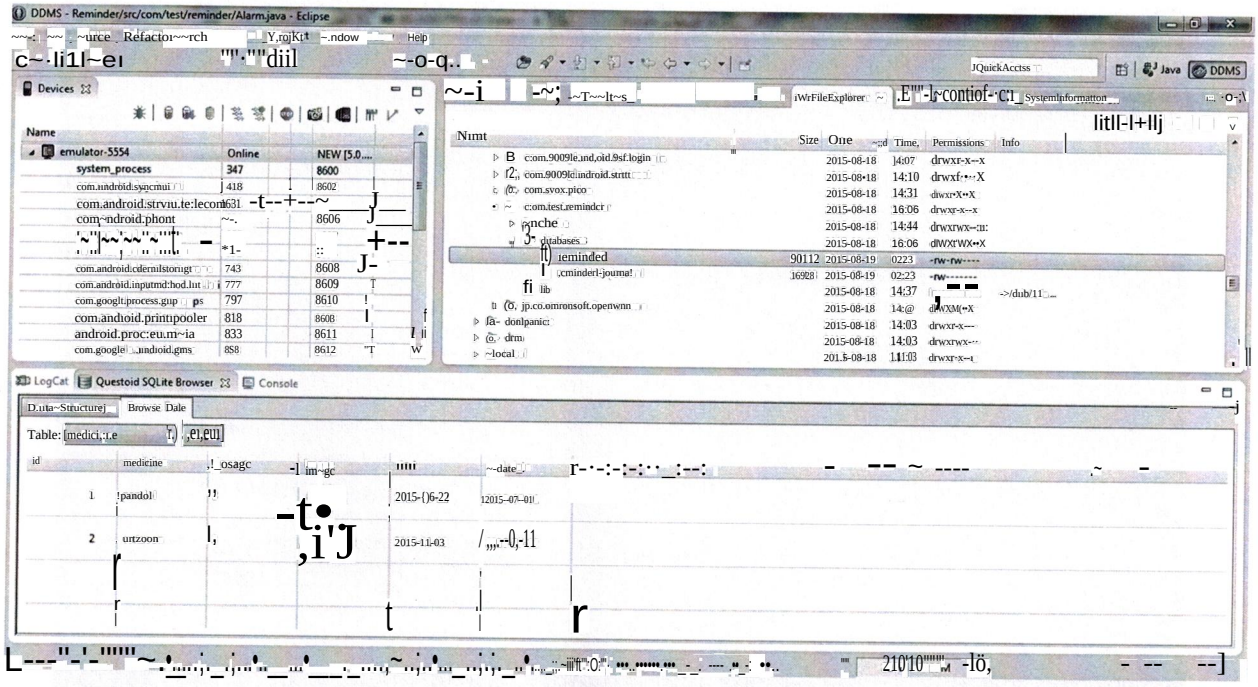



Figure 4.5: Screenshot of ADK

### 4.4. Developed System Operation

The developed system work in two interfaces, which the Doctor's interface and the Patient's interface.

- **The Doctor's Interface:** When the patient comes to the hospital, after several diagnoses, the doctor gives the patient prescription using the patient details to register the patient in the administration side of the developed system and after that give the patient his/her prescription with usemame and password and also with the link to download the developed application. After the patient have registered using the given details, automatically the patient details will show in the administration side with a given Phone ID number. From there the doctor screen, he/she can see whatever the patient is doing and even send a message across in case of non-adherence to medication situation occurs (Figure 4.6).

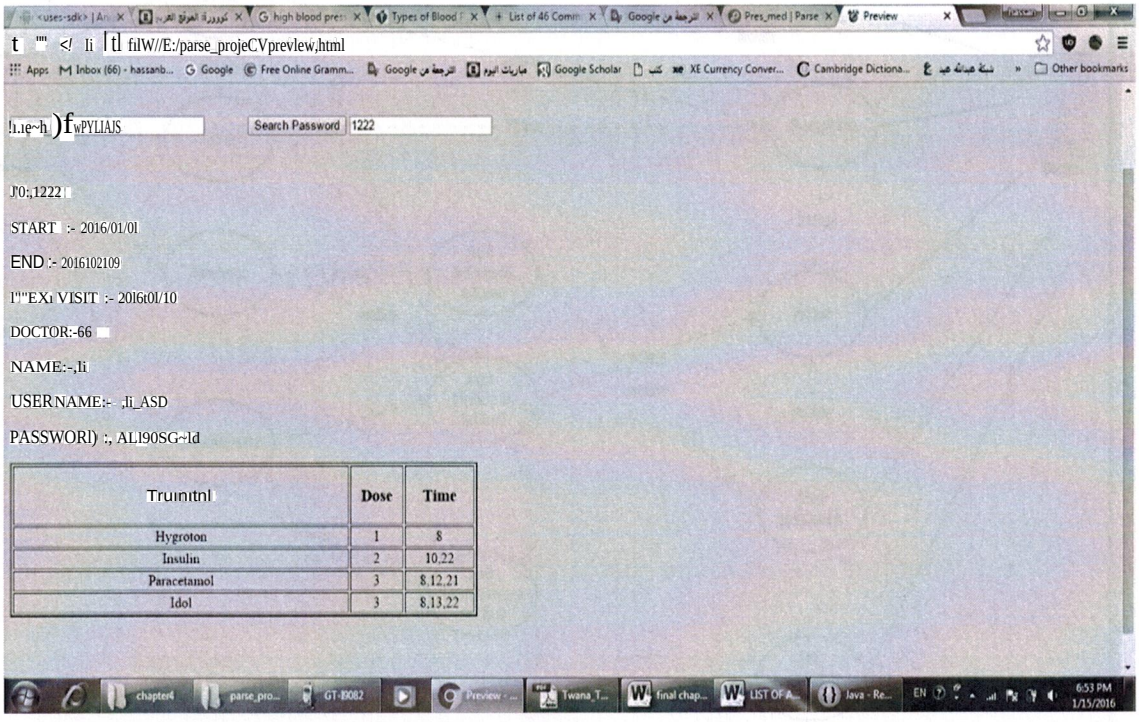



**Figure 4.6:** Screenshot of patient's prescription and registration details

- **The Patient's Interface:** After leaving or in the doctor's office the patient can download the developed mobile application and register using the usemame and password given to him/her by the doctor. After that he/she can register the prescribed

drugs and set the alarm. The patient can also lay any complaint to the doctor via the system.

### 4.5 Use-Case Diagrams

The use-case system illustrated the system design, which it is a way of better understanding the system actions of the users and it explains how the user uses the system. It also shows the relationship between the users and other subsystems (Figure 4.7).

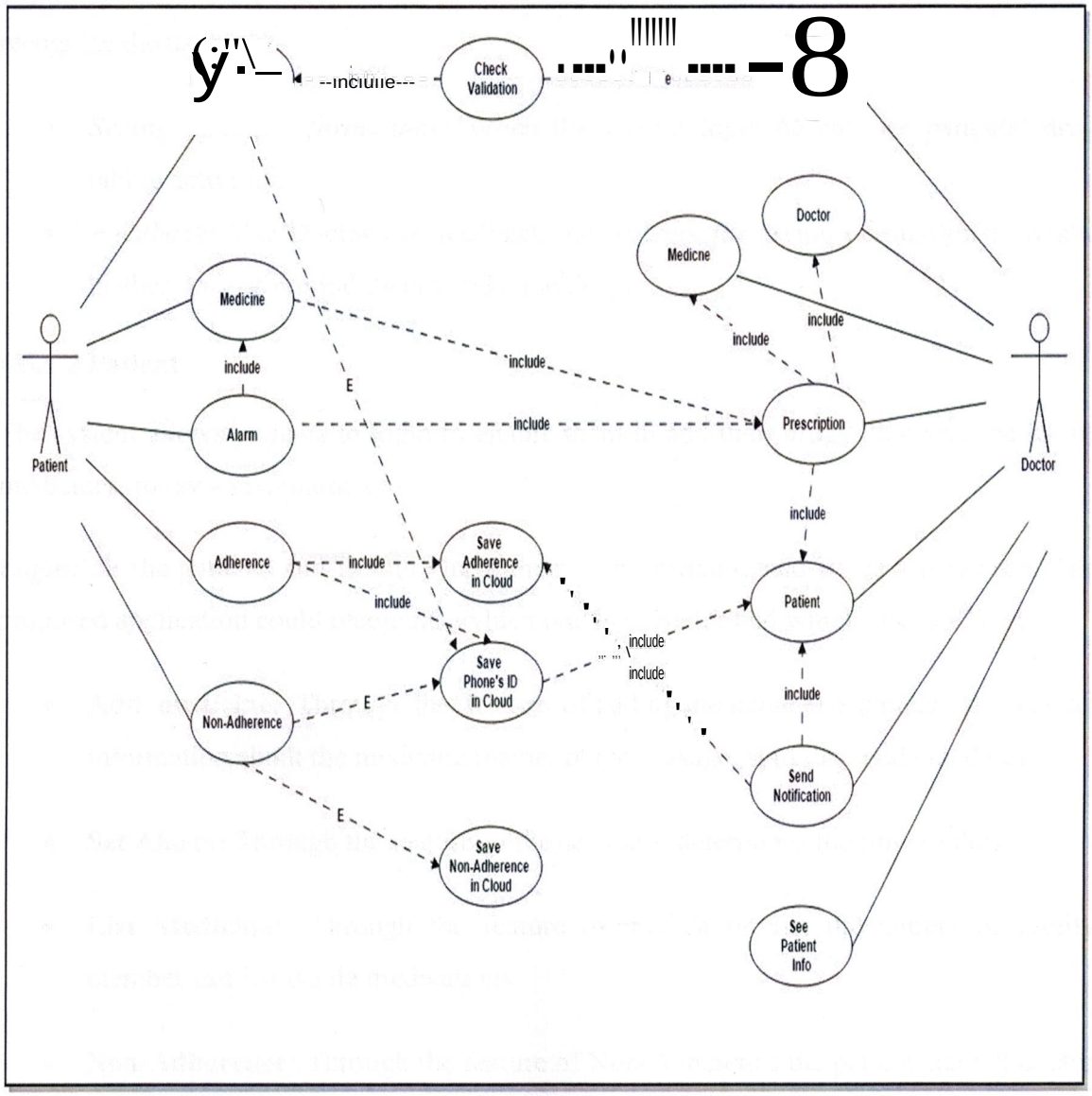



**Figure 4.7:** System controller (patient) and the doctor side of the developed system

### 4.5.1 System user

The system has two types of users, doctor and patient, which they can login into this system. The administrator already puts doctors and patients' information into the cloud.

#### 4.5.1.1 Doctor

The Doctor's role in this application pointed out below:

*Login:* the system permits the doctor to login which the system automatically can recognize the users.

- *Seeing patient's formations:* When the Doctor login he can see patients' drug taking activities.
- *Feedback:* The Doctor can feedback the patients for giving permission to retake his/her drug or remind them to take the drugs.

#### 4.5.1.2 Patient

The system allows patients to login to enable them to add their drugs, to check the list of medicines, to lay a complaint, etc.

*Login:* all the patients and Doctors have their own usemame and ID as a password. The proposed application could recognize, which one is a Doctor and which one is a Doctor.

- Add medicine: Through the feature of adding medicine the patient can add all information about the medicine (name, photo, dosage, start date and end date).
- Set Alarm: Through the feature of the set alarm determines the time of doses
- List Medicines: Through the feature of medication list the patient or family member can list whole medications
- Non-Adherence: Through the feature of Non-Adherence the patient can tell doctor reason, since he/she medicine non-adherence.
- Find Alarm: Through the feature of finding doses' time for medicine
- Send notification: The doctor can send notifications to specific (user and area).

### 4.6 System Requirements

The system needs some of hardware and software tools, such as computer tools and mobile device.

#### 4.6.1 Computer tools

The tools are used for developing the Alarm mobile application as follows:

1- HP DV6 laptop based on Windows 7 (32 bit) operating system was used.

2- Eclipse-Iava-Juno-SR2 version 4.2.1 software for editing the project codes.

3- Java Development Kits (JDK) - version 8 with eclipse to compile and deploy the application using Java programming language code.

4- (Android-SDK 5.0.1 (API 21) is needed to develop the application for Android and it includes tools of (libraries, debugger, emulator, etc.).

5- Android Virtual Device (AVD- BlueStacks version 0.10.0.4321) as an emulator for showing and previewing the run of the application

#### 4.6.2 Android device

The application is suitable for Samsung Galaxy Grand DUOS 19082 devices which have these features:

**Version:** 4. 1.2
**Size:** 5.0 inches
**Resolution:** 480 x 800 pixels
**Dimensions:** 143.5 x 76.9 x 9.6 mm
**SIM:** Dual SIM
**CPU:** Dual-core 1.2 GHz Cortex-A9

# CHAPTERS

# SYSTEM IMPLEMENTATION

A mobile device (basically, Android) is used by medical patients (i.e. People on medication) for adherence to their medications (drugs). So therefore a software that can enable them to do that effectively without stress and struggle will be duly appreciated by them. This application is a medical reminder application that enables patients to take their drugs by reminding intervals of hours. This application can enable then add medicine, set/find alarm, list medicines, makes feedback through non-adherence, send notification, etc.

## 5.1 System Features and Users

The system has two types of users, doctor and patient, which is made up of various features. The administrator already puts doctors and patient's information into the cloud. The developed system will be discussed in two interfaces using a case study of a patient that is prescribed 3 dosages of paracetamol for three times per day by the doctor. But first the various users and features of this system are listed below.

**User:** Doctor

**Features:** Login screen; Patient's information screen on cloud; and Feedback screen

**User:** Patient

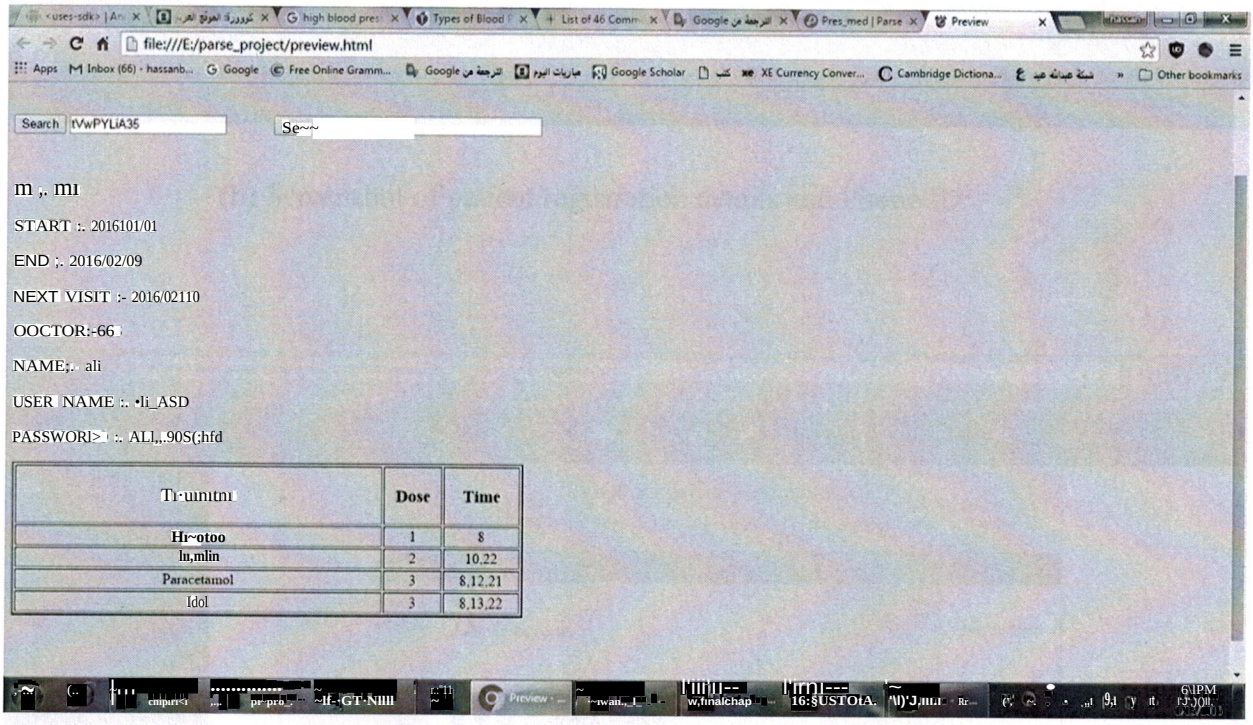
**Features:** Registration page; Login screen; Add medicine screen; Set Alarm screen; List Medicines screen; Non-Adherence screen; Find Alarm screen; Send notification screen and work-offline screen.

## 5.2 Doctor's Interface

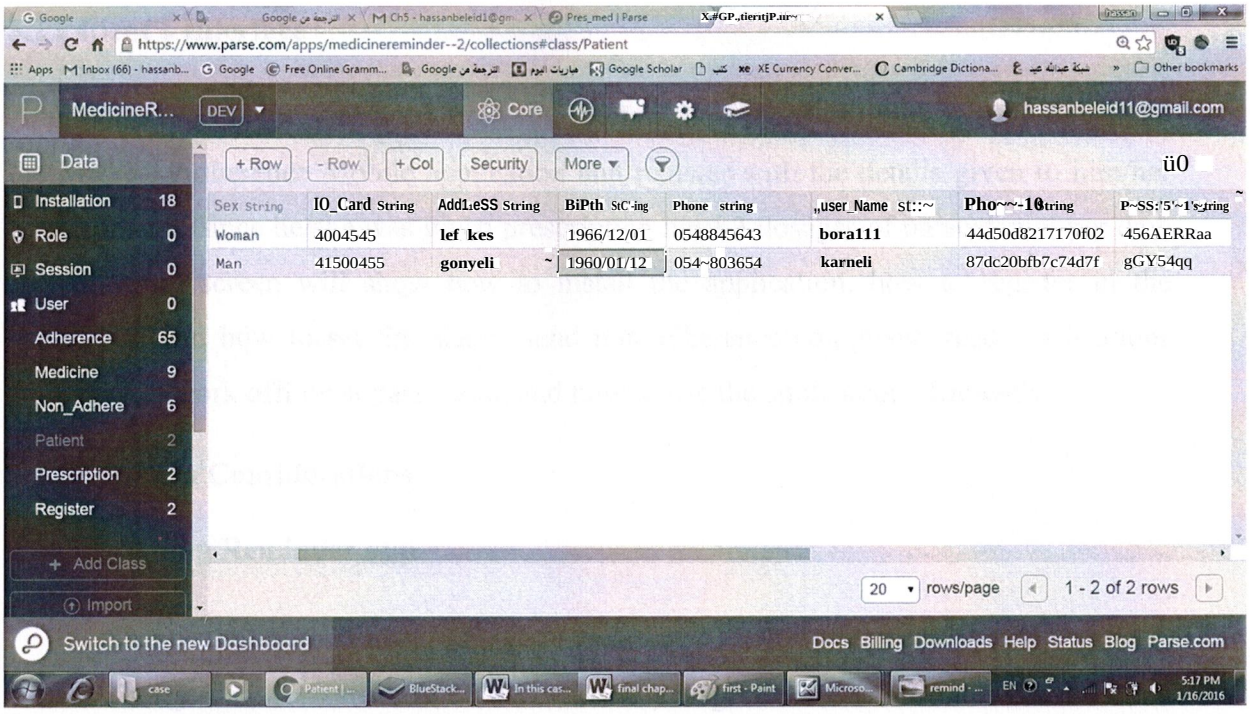
The doctor is one of the administrators of this system, which he/she can control patient's information and watching patients' behavior. The doctor can also remind the patient to take their drugs, if they skipped it.

When the patient visits his/her doctor, after several diagnoses, the doctor will write a prescription as shown below (take, for instance, a patient is given prescription having in it,

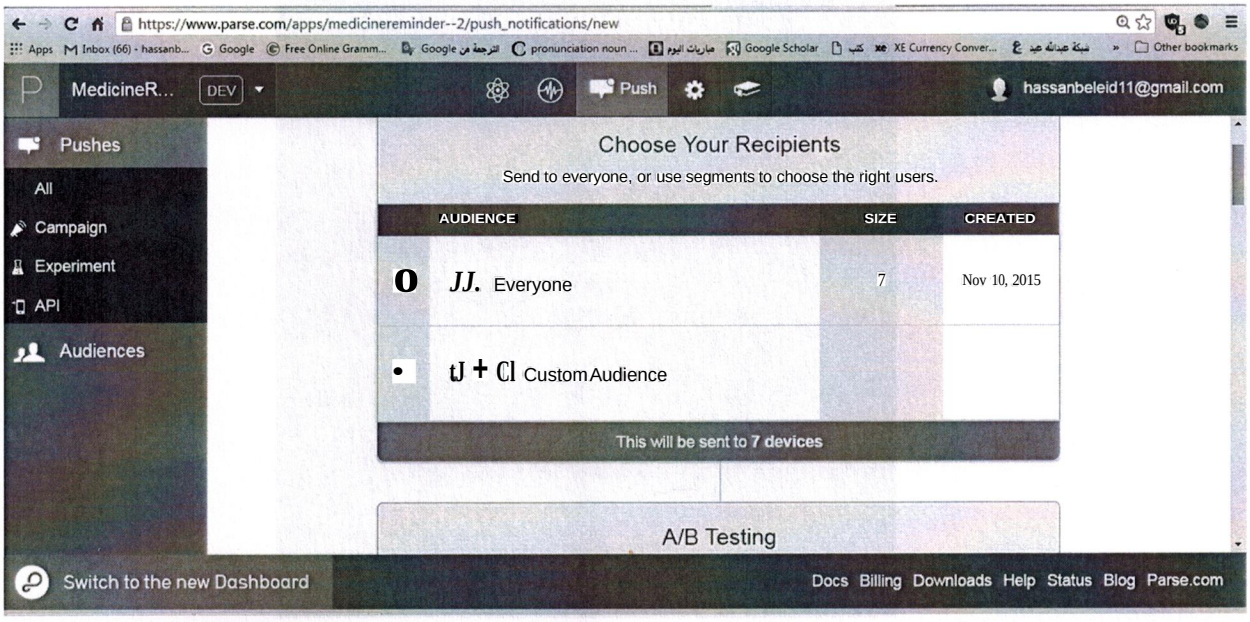
3 dosages of paracetamol for three times in a day, i.e. 8am, 12pm, 21pm-Figure a). And register the patient with a specific username and password and give the patient the user name and password. When the patient download the application and login with the username and password, and afterwards the patient can go the pharmacy to get the Paracetamol and register the it in the system. Automatically a Phone ID will show in the administration side with the details of the patient, and through that ID the doctor can easily communicate back to the patient (Figure b). From that screen, the doctor can see whatever the patient is doing and even send a message across in case of non-adherence to medication situation occurs. Also the doctor can send notification to patient to remind then to take their drug of to come for follow-up appointment (Figure c).




(a) Screenshot of patient registration details and drug prescriptions




**(b)** Screenshot of patient registration details and Phone ID




(c) Notification sending to patient by doctor

**Figure 5.1:** Prescriptions, patient registration and notification sending to patient by doctor

## 5.2 Patient's Interface

After collecting the prescriptions from the Doctor, the patient can immediately download the Medical Adherence Mobile application and register with the details given to him/her by the doctor. Since he/she was given prescription have 3 dosages of paracetamol per day, the following screen will show how to install the application, how to register in the application and how to set the alarm, send non-adherence compliant, read notifications from doctor, work offline at parse.com, and how to use the application efficiently.

### 5.2.1. System Considerations

**After installing Reminder app**

- Change time format into 24 Hours.
- Change date format into (YYYY/MM/DD). Figure 5.2 demonstrates the time and the date format.

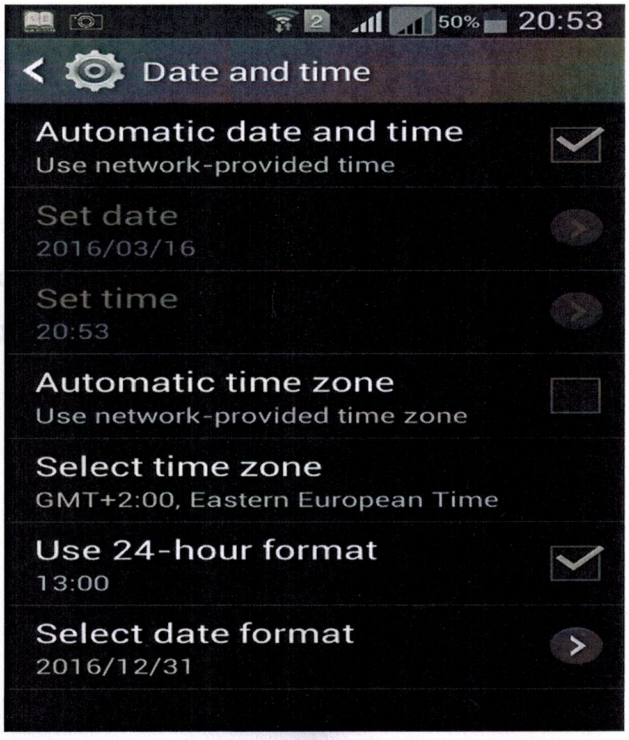



**Figure 5.2:** A snapshot of the date and the time format

- And take the paracetamol's photo. Figure 5.3 demonstrates paracetamol's photo.

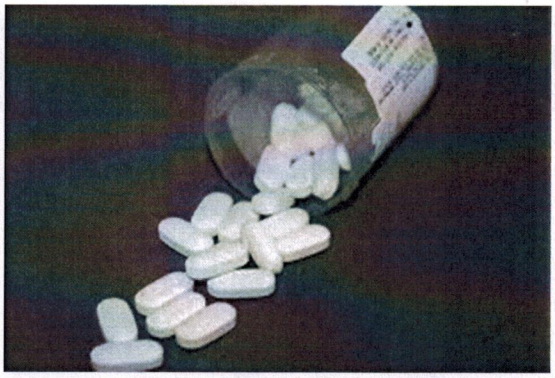


**Figure 5.3:** Photo of the paracetamol

- After that patient start using the application
- Click on icon installed on the phone

- After that first screen come up

### 5.2.2. Login Screen

After which the patient login with the details given to him/her by the doctor and start upload the drug photo and setting the alarm for the paracetamol. Figure 5.4 shows a patient's login screen.

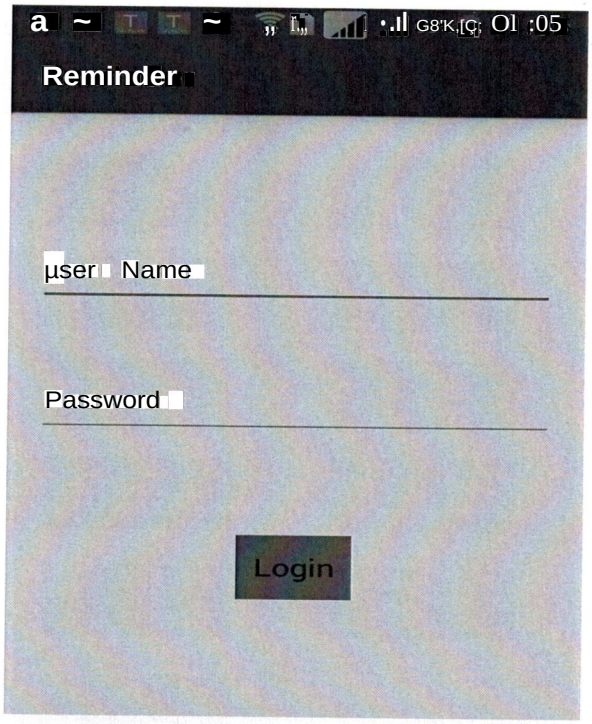



**Figure 5.4:** A snapshot of the login screen

### 5.2.3. Home Screen

After successfully login, the home page of the patient appears, showing; Phone REG, Add Medicine, Set Alarm, List Medicine, Update, Med Show, Del Med, Non-Adhere, Find Alarm, Alarm Del. And also when the doctor login, his/her home shows the various registered patients in the system. The Figure 5.5 shows the Patient's actions as follows:

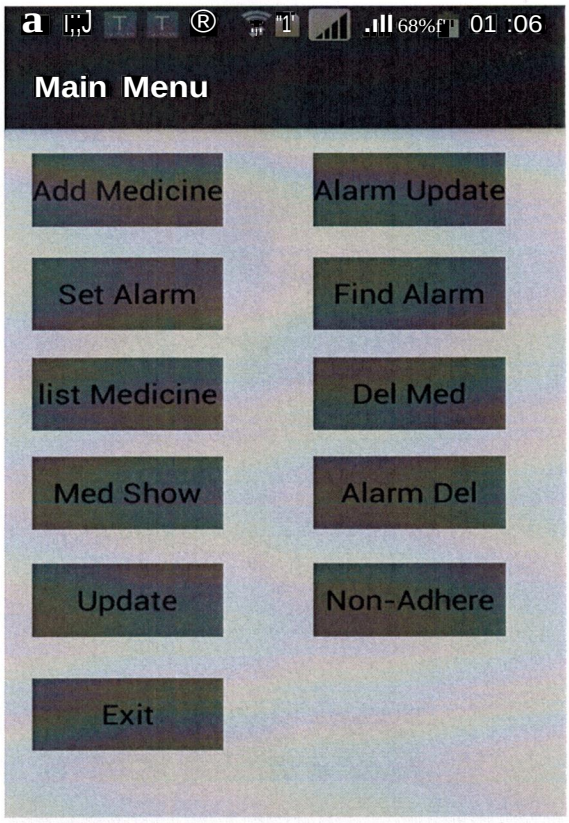



**Figure 5.5:** A snapshot of the main menu of patient

### 5.2.4. Add Medicine Screen

After registration in the Medical Adherence application, the patient should click on the "Add Medicine Icon" to add the paracetamol, set drug dosage and add drug delivery period. On this screen, the patient can add the paracetamol prescribed for him by the doctor. Figure 5.6 shows the snapshot of patient adding the paracetamol to the system. This interface update alarms, The Figure 5.5 shows the Patient' actions as follows. On this screen the patient can upload the picture of the paracetamol, add the dosage (such as 3 dosages per day) and add the drug delivery period (i.e from on the 2016/01/10 to 2016/03/20). Then the patient should click on "Load Img" to add the paracetamol image. When the image has uploaded, he/she can then click on "save button" and click back to return to main menu.


**Figure 5.6:** Screenshot of Patient adding paracetamol, setting the dosage and delivery period

### 5.2.5. List Medicine Screen

After addition of the paracetamol drug, setting the dosage and adding the delivery period, the patient can click on the "List Medicine Icon" to see the added medicine, the dosage and the delivery period (Figure 5.7). And then click on "Display button" on the "List Medicine Screen" to see added drug information showing medicine ID, which is "ID = (6)" for this study. Then when he/she is done, the patient can then click on "Back button" to go back to home page.

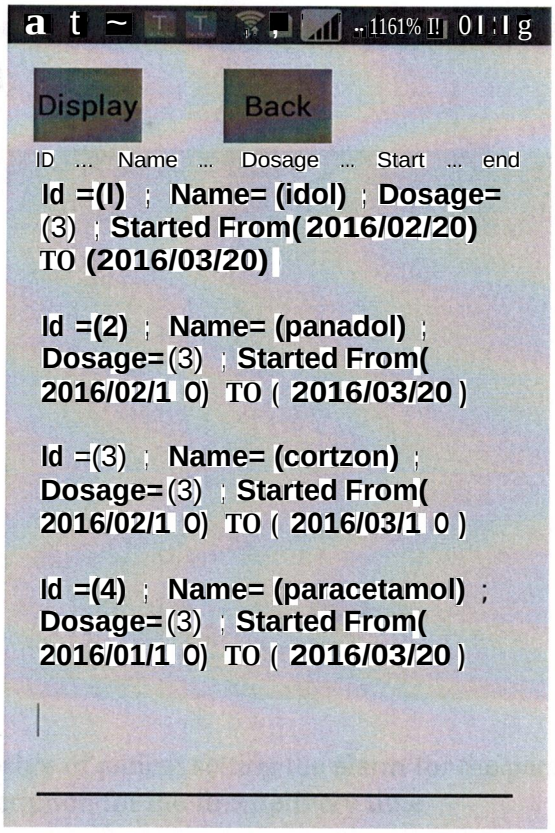
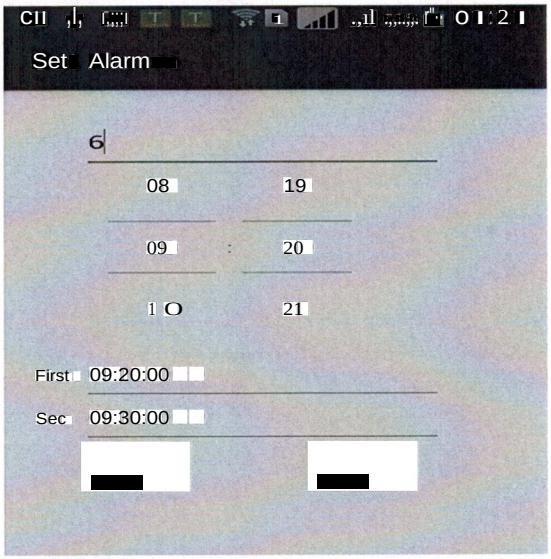



**Figure 5.7:** Snapshot of List of Medicine Screen with Display and Back button on it

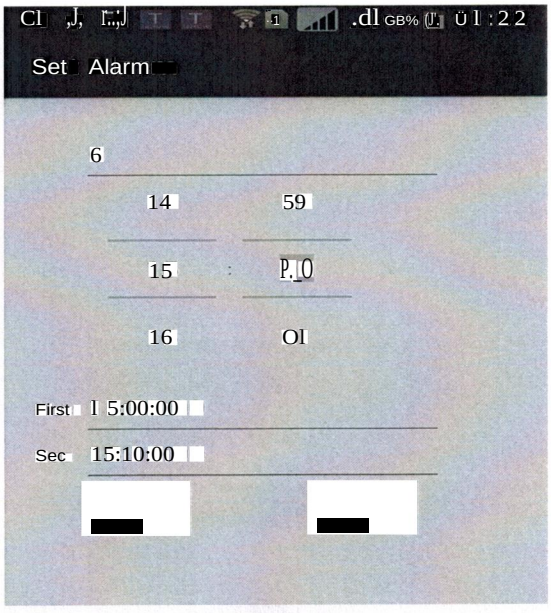
### 5.2.6. Set Alarm Screen

After the patient has successfully added the drug and check to see if the drug has been added. The patient can then click on "Set Alarm Icon" on the home page using the medicine ID number, which is 6. On this page the patient can set the alarm, according to the prescription details given to him/her by the doctor, by adjusting the time-tab, from the first dose to second dose. Then click on picker time to change the alarm time to for example 09:20:00. The alarm will start at 09:20:00 and finish after 10 minutes at 09:30:00 and click on "Save button" for first delivery time. Then change to a second delivery time by clicking on picker time, then Save for example 15:00:00. Second alarm will start at 14:30:00 and finish 10 minutes at 15:10:00 and click on "Save button". And the third delivery time at 22:30:00 and finish 10 minutes at 22:40:00. After setting the alarm following doctor's order the patient can then click on "save button" to save the alarm set and click "back button" to return back to main menu (Figure 5.8a, 5.8b and 5.8c). Then the Alarm screen will appear if the alarm set match with the SQLite saved time (Figure 5.8d). In the alarm screen, the patient can click on "I took it" once the alarm state ringing

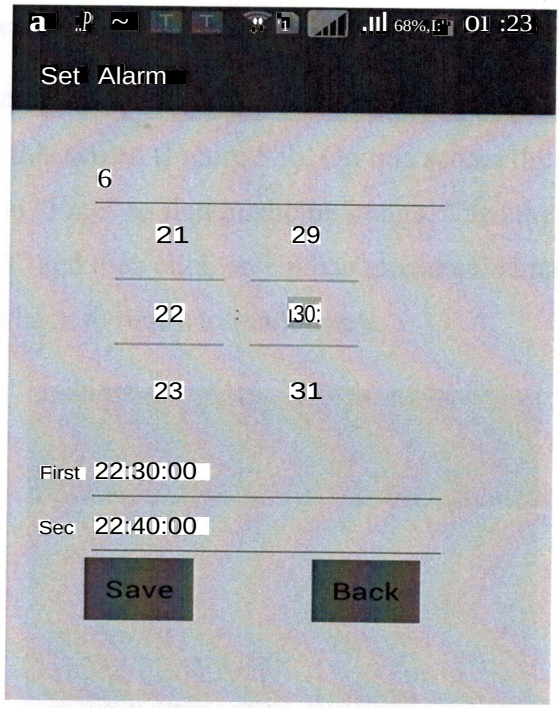
or click on "Not yet" on the alarm screen page, then the alarm will ring again in the next 10 minutes (Figure 5.8d).



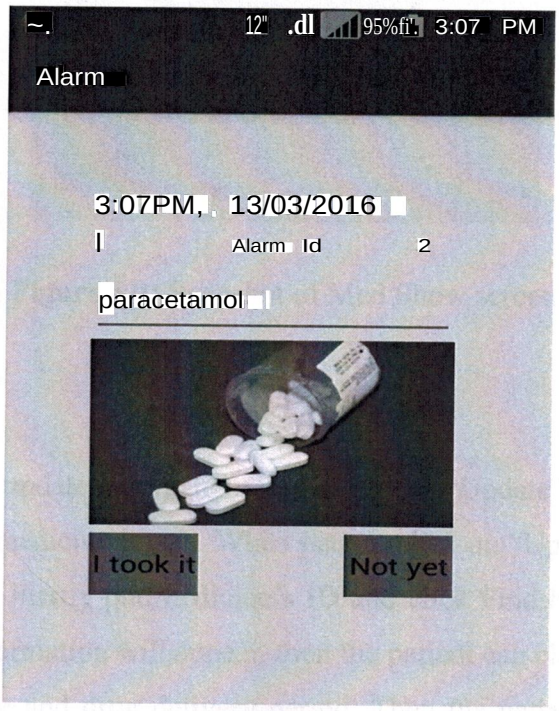

(a) Snapshot of patient setting the alarm for the paracetamol prescription for the first delivery time




(b) Snapshot of patient setting the alarm for the paracetamol prescription for the second delivery time




(c) Snapshot of patient setting the alarm for the Paracetamol prescription for the third delivery time




(d) Alarm pop-up when ringing screenshot

Figure 5.8: Setting alarms for the paracetamol and alarm ringing

### 5.2.7. Med Show Screen

After setting the alarm and taking the drug, then the patient can click on "MED Show" in the main menu to show this screen (Figure 5.9). On this screen the patient can put the medicine ID and click on "Find" to find medicine Image. Then the patient can change the image by click on "IMG" and then click on Update medicine's image to update medicine image and then click on back to return to main menu.

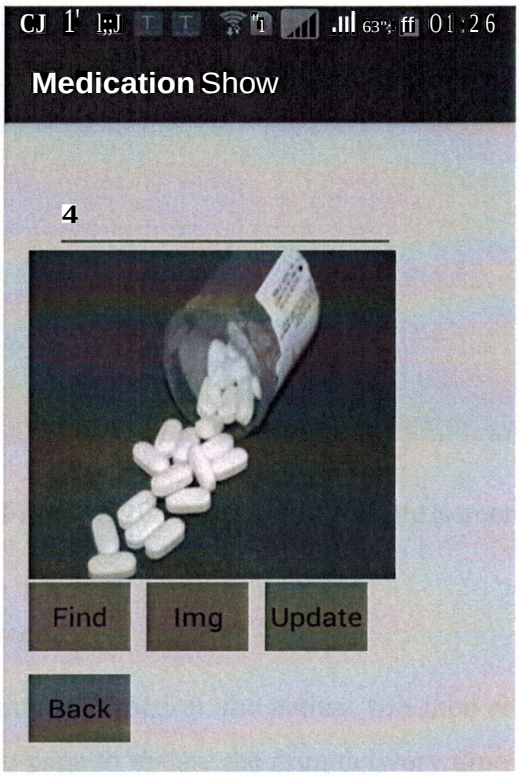



**Figure 5.9:** Snapshot of Med Show screen

### 5.2.8. Update Screen

After medicine image update, the patient can click on "Update" on the main menu to search for the updated medicine image. When patient click on "Update" in the main menu will appear this screen. Firstly put medicine's ID and click Find button to find medicine, then the medication information will appear, then the patient can change the medicine's ID and possibly the dosage and drug delivery period. Then the patient can click on Update button finally and then click on Back button to back to main menu (Figure 5.10).

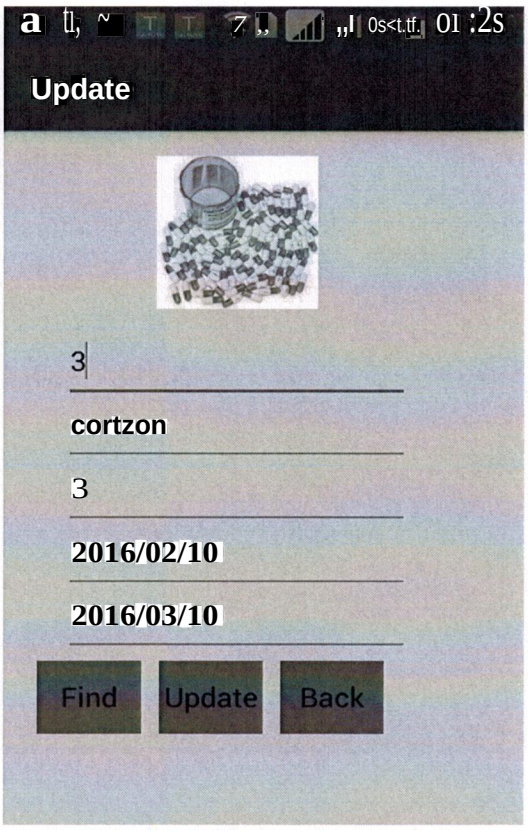
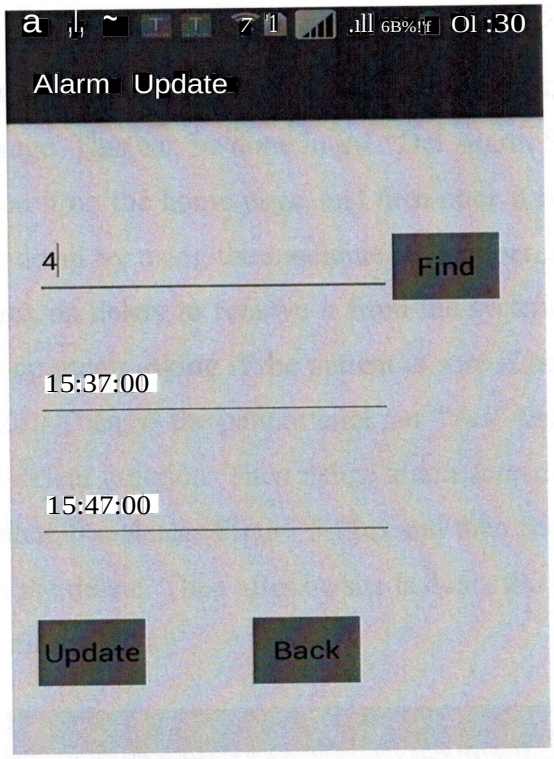


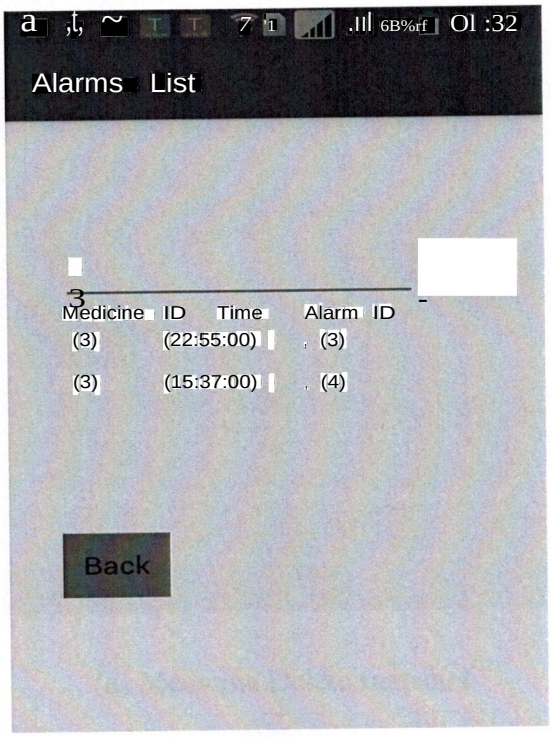

**Figure 5.10:** Snapshot of Update Screen

### 5.2.9. Alarm Update Screen

Then after updating the drug information, the patient will then click on the "Alarm Update Screen" on the main menu page to update the drug delivery time for the prescription given to him/her by the doctor (Figure 5.11a and 5.11b). The patient will then input the medicine ID and click "Find Icon" to search for the medication details (Figure 5.11b) and then click on "back icon" on "Find Screen" to return to "alarm update screen". After the medication details are loaded the patient can now adjust the drug delivery time, to the desired time as prescribed by the doctor (Figure 5.11 a).




(a) Alarm Update Screenshot

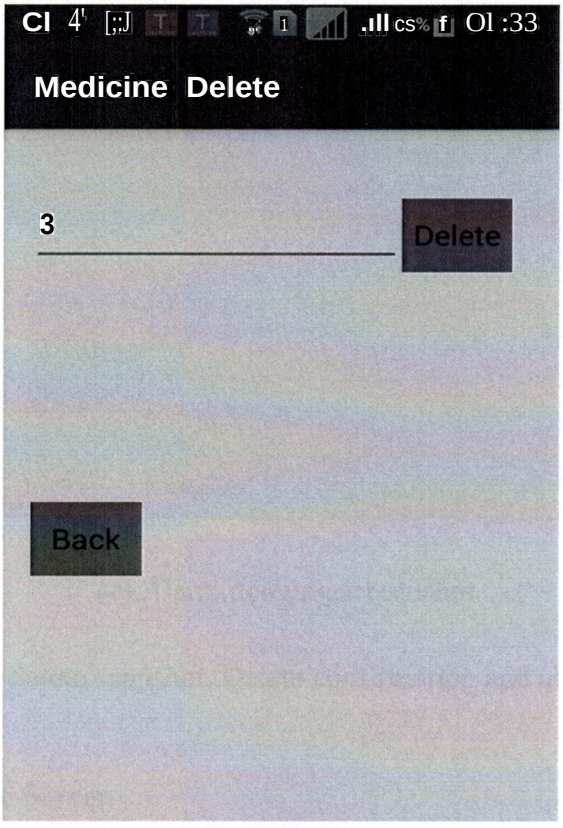



(b) A screenshot of Find alarms for medicine

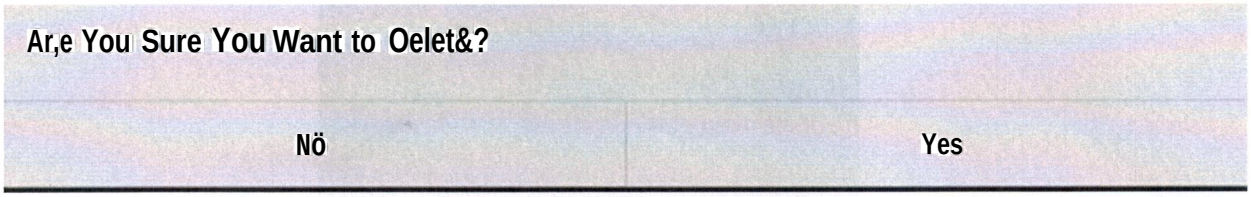
Figure 5.11: Alarm Update Screenshot and Find alarms for medicine

### 5.2.10. Medicine Delete Screen

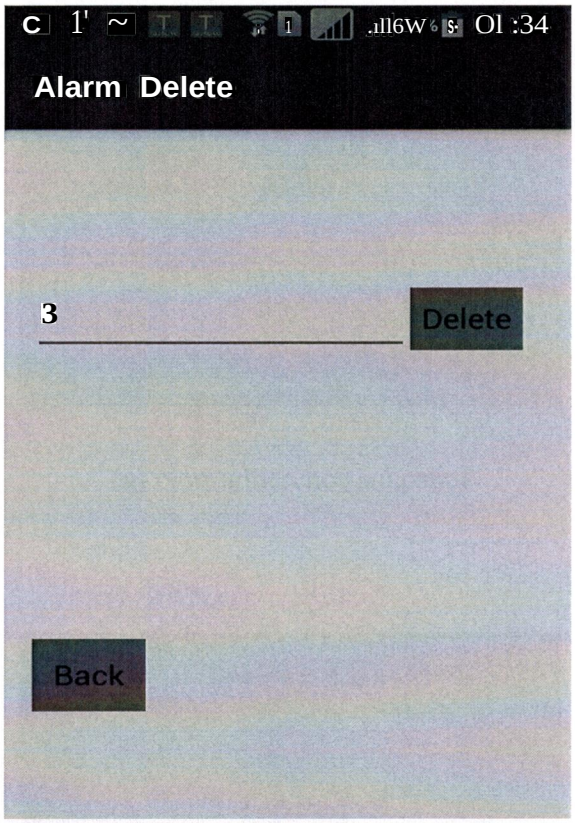
After updating the alarm, the patient can as well delete the drug maybe after finishing the dosage and add new dosage. This can be done in the "Del Alarm Screen". The patient can open the page by click on it on the home page, and then once it is opened the patient can then search for the drug detail by using the medicine ID number, which is (6) in this case (Figure 5.12a). Then click on delete to remove it from the system. Once the patient click on delete there is a pop-up menu asking if the patient is sure if he/she wants to delete the drug or not (Figure 5.12b). Then, if the patient click on "Yes" the drug will be deleted or click on "No" to cancel delete function. Then delete alarm screen will then appear for the patient to completely delete the alarm (Figure 5.12c) and then the confirmation page will pop-up again to confirm the delete. Then after he/she is done, the patient can then click on "back icon" to return to main menu.




**(a)** Medicine Delete snapshot




**(b)** Delete confirmation pop-up menu snapshot

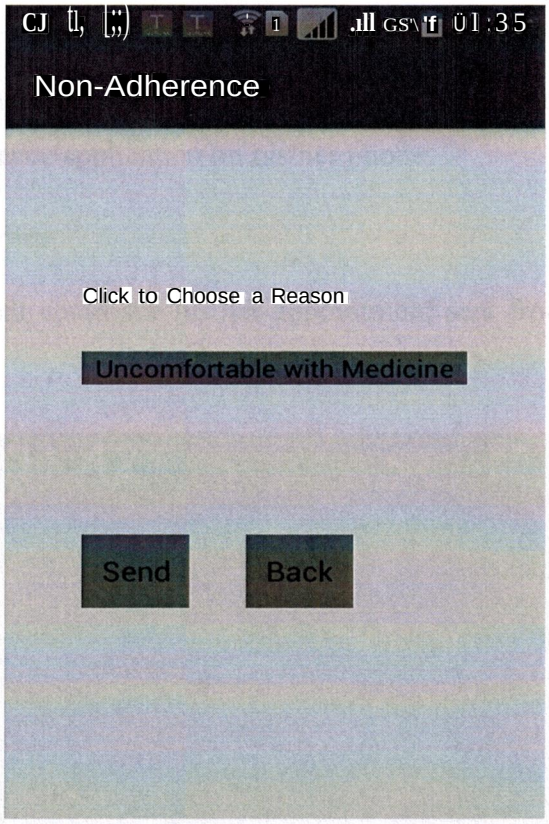



**(c)** Alarm deleting screenshot

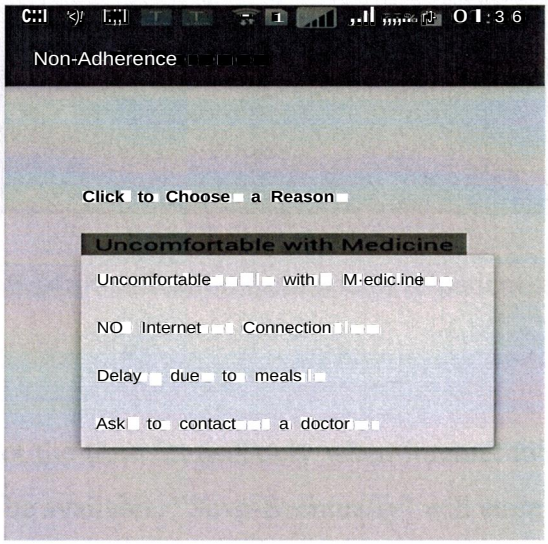
**Figure 5.12:** Medicine delete snapshot, Delete confirmation and alarm deleting screenshot

### 5.2.11. Non-Adherence Screen

On the screen, the patient can give feedback to the doctor on the reasons why he/she is yet to take his/her medication. Possible reason could be "un-comfortability with drug, internet problem, due to a delayed meal", then the patient could select his/her reasons from the combo box and then send back to the doctor (Figure 5.13a, and 5.13b). After that the patient can click on "back icon" to return to main menu.




(a) Non-adherence snapshot




**(b)** A combo box of non-adhere

**Figure** 5.13: Non-adherence and combo box of non-adhere

### ·5.2.12. Exit Screen

After everything is done the patient can then click on "Exit Icon" on the main menu to close the medical adherence application on his/her phone.

### 5.2.13. Notification Screen

On the screen the patient could see his/her appointment sent from the doctor to him/her (Figure 5.14).

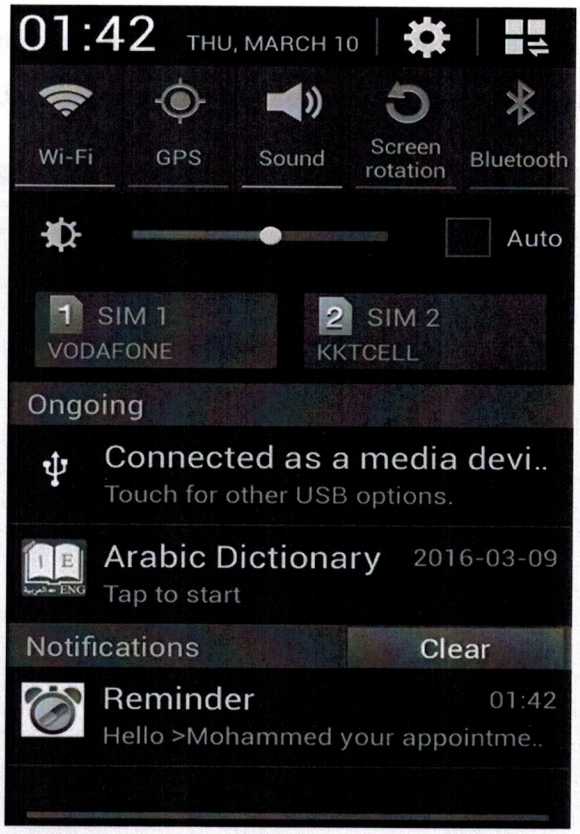



**Figure 5.14:** Notification from doctor to patient snapshot

## 5.3 Work offline

The patient can either set the time immediately when internet available or pending when internet connection will be available. "Save-Eventually" will store the update on the device until a network connection is re-established. If your app is closed before the connection is back, Parse will try again the next time the app is opened. And the code the program his feature is shown below:

```
Parseübject  dataübject  = new Parseübject("Adherence");
                        dataübject.put("Device _Id", rn_szAndroidID);
                          dataübject.put("Medicine _Narne", name_med);
                          dataübj ect.put("At_Tirne", rnydate);
                          dataübject.put("Dosage _Time", datal );
                    dataObject.saveEventually();
```

## 5.4 Multi options Screen

The doctor can manipulate with raw data inside cloud parse.corn or use interface (web page which is built on JavaScript). The Figure 5. 15 shows the Doctor's actions as follows.

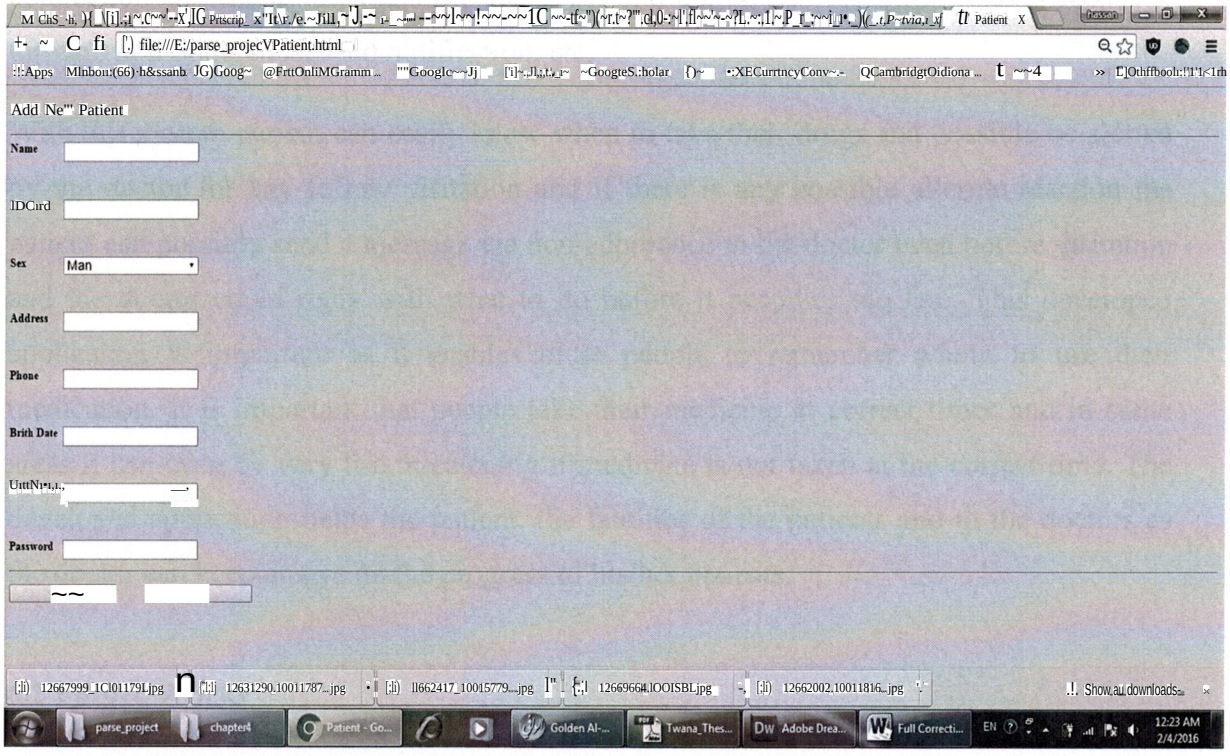



Figure 5.15: A snapshot of Multi-tasking options

# CHAPTER6

# CONCLUSION AND FUTURE WORKS

## 6.1 Conclusion

In this thesis a medication reminder system has been developed for patients. The system helps the patients to register, login, add drugs, set alarm for drugs, etc. The system is operated through cloud platform via the mobile device. With the help of the developed system a So therefore a software that can enable them to do that effectively without stress and struggle will be duly appreciated by them. This application is a medical reminder application that enables patients to take their drugs by reminding intervals of hours. This application can enable then add medicine, set/find alarm, list medicines, makes feedback through non-adherence, send notification, etc.

With this system patient can easily know when to take their drugs and possible be alerted by the doctor for any follow visitation and if there is any possible allergic reaction the patient can possibly send a message via non-adherence to the doctor even before visitation and the doctor could reply with what to do before it becomes too late. This developed application is important as it enables older people to remember whom to use their medication. It is important that people take their medicine at correct times and in some areas it can even be very life threatening if medicine is not taken at the correct time. The developed application helps the patient, the families of the patients and to the doctors as the doctor can keep an eye on the progress of his/her patients.

## 6.2 Future Works

The application can be progressed from these aspects:

- Developing the same application for other operating systems such iOS, etc.
- It is possible to make the being operated by the doctor via his/her mobile phones.
- It is possible to generate usenıame and password automatically.
- It is possible to link server side with pharmacies.
- It is possible to add administratorfor this applicationto add and edit the users.

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# APPENDICES

## APPENDIX A

## INTERFACES OF DEVELOPED SYSTEM

The interface programming of the developed system is created through XML files. Bellow the source codes of the interfaces (XML files) is shown.

```
<Relati veLayout xmlns: android="http ://schemas.android. com/ apk/res/ android"
   xmlns:tools="http://schemas.android.com/tools"
   android:layout_ width="match _parent"
   android:layout_ height="match _parent"
   android:paddingBottom="@dimen/activity _vertical_ margin"
   android:paddingLeft="@dimen/activity _horizontal_ margin"
   android:paddingRight="@dimen/activity _horizontal_ margin"
   android:paddingTop="@dimen/activity _vertical_ margin"
   android: background="#d0e4 fe"
   tools:context="com.test.reminder.Medicine" >
   <Image View
      android:id="@+id/Image ViewO 1"
      android:layout_ width="280dp"
      android:layout_ height="l 50dp"
      android:scaleType="fıtXY">
      </Image View>
   <EditText
      android:id="@+id/ dosage"
      android:layout_ width="wrap _content"
      android:layout_ height="wrap _content"
      android:layout_ alignLeft="@+id/lmage ViewO 1"
      android:layout_ alignParentRight="true"
      android:layout_ below="@+id/medicine"
      android:ems="l 0"
      android:hint="Dosage Number in Day"
      android:inputType="number" />
```

```
<EditText
    android:id="@+id/medicine"
    android:layout_ width="wrap _content"
    android:layout_ height="wrap _content"
    android:layout_ alignLeft="@+id/dosage"
    android:layout_ alignParentRight="true"
    android:layout_ below="@+id/lmage Viewü 1"
    android:hint="Madicine Name"/>
<EditText
    android:id="@+id/start"
    android:layout_ width="wrap _content"
    android:layout_ height="wrap _content"
    android:layout_ alignLeft="@+id/end _date"
    android:layout_ alignRight="@+id/medicine"
    android:layout_ below="@+id/ dosage"
    android:hint="Start Date(Y ear/Month/Day)"
    android:inputType="date" >
    <requestF ocus />
</EditText>
<EditText
    android :id="@+id/ end_date"
    android:layout _ width="wrap _ content"
    android:layout_ height="wrap _content"
    android:layout_ alignLeft="@+id/load _image"
    android:layout_ alignRight="@+id/medicine"
    android:layout_ below="@+id/start"
    android:ems=" 10"
    android:hint="End Date(Y ear/Month/Day)"
    android:inputType="date" />
</Rel ativeLayout>
```

## APPENDIXB

## JAVA SOURCE CODES

The source codes of the developed application are written by Java language programming. The source codes are saved in Java file which each file has a main class. This section shows the important source codes of the files.

### Check password, user name and register phone id.

```
String par= us.getText().toString();
String parl = pass.getText().toString();
if (par.matches("") || parl .matches("") ){
Toast.makeText(getBaseContext(), "Please fill out both field",
Toast.LENGTH_ LONG).show();
}
else {
        ParseQuery<ParseObject> query= ParseQuery.getQuery("Patient");
                query. whereEqualTo("U ser_Name", par);
                query. whereEqualTo("Password", parl );
                query.getFirstlnBackground(new GetCallback<ParseObject>()
                                {
@Override
public void done(Parseübject Patient, ParseException e) {
        if(e == null)
          {
        Patient.put("Phone _ID", PhoneID);
        Patient. savelnB ackground();
    startActivity(new Intent(MainActivity.this, Main_Menu.class));
        }
                                        else
                                        {
                                         if( e.getCode() ==
ParseException.OBJECT_NOT_FOUND)
                                         {
```

```
Toast.makeText(getBaseContext(),"User Name or Password isn't Correct",
Toast.LENGTH_LONG).show();
                    }
    else
                                        {
                                          }
                                        }
```

**Save Adherence in cloud**

```
getWindow().addFlags(WindowManager.LayoutParams.FLAG _DISMISS _KEYGUARD |
                    WindowManager.LayoutParams.FLAG _SHOW_ WHEN_ LOCKED |
                    WindowManager.LayoutParams.FLAG _TURN_ SCREEN_ ON |
                    WindowManager.LayoutParams.FLAG _KEEP_ SCREEN_ ON);
setContentView(R.layout.activity _alarm);
            mp= MediaPlayer.create(Alarm.this, R.raw.a);
                mp.start();
          mp. setLooping( true);
          update =new DatabaseHandler(getBaseContext());
         sub.setOnClickListener(new View.OnClickListener() {
                        InputStream is=null;
                        @Override
                        public void onClick(View v) {
                        Intent i =getlntent();
 String datal =i.getStringExtra("sdt");
 final String mydate =
java.text.DateFormat.getDateTimeinstance().format(Calendar.getlnstance().getTime());
 final String m_szAndroidID = Secure.getString(getContentResolver(),
 Secure.ANDROID _ID);
                                String name_med=""+med_idl .getText().toString();
                                ParseObject dataObject = new ParseObject("Adherence");
                                  dataObject.put("Device_Id", m_szAndroidID);
                                  dataObject.put("Medicine _Name", name_med);
```

```
                    dataübject.put("At_Time",    mydate);
                    dataübject.put("Dosage    _Time",  datal );
                    dataübject.saveEventually();
```

**Retrieve image from SQLite**

```
public void onStart() {
        super.onStart();
          pho = (ImageView)fındViewByld(R.id.alarm_img);
         String startı =med_idl .getText().toString();
        db=openürCreateDatabase("reminderl  ",MODE_PRIVATE, null);
       Cursor c1= db.rawQuery("SELECT *FROM medicine    WHERE id="'+startl +'"
", null) ;
        if(cl .moveToNext()){
              String    namel  = cl .getString(l );
               med_idl .setText(namel );
               byte[] image   =cl .getBlob(3);
               Bitmap bmp =BitmapFactory.decodeByteArray(image, 0, image.length);
               pho.setlmageBitmap(bmp);
              }
```