İSTANBUL KULTUR UNIVERSITY ★ INSTITUTE OF SCIENCE

C-DRUG: A MEDICATION USAGE CONTROL SYSTEM

M.Sc. Thesis by
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Programme : Computer Engineering

Thesis Supervisor: Prof. Dr. Coşkun BAYRAK

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C-DRUG : İLAÇ KULLANIMI KONTROL SİSTEMİ

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FOREWORD

I want to extend my appreciation to my advisor, Prof. Dr. Coşkun Bayrak, for his time, guidance, and knowledge. Also thanks are extended to my committeee members for their valuable times and comments. At the same time, I want to present my grateful to my precious wife, Zeynep, my family and one of best friend, Nihat, to support me all the time, during this process.

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Computer Engineering

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ABBREVIATIONS

C-DRUG **:** A Medication Usage Control System
HRS **:** Hospital Record System
PIS **:** Patient Information System
PTS **:** Patient Tracking System
NS **:** Notification System
IDC **:** Intelligent Drug Container
MTS **:** Mobile Tracking System
WHO **:** World Health Organization
SSI **:** Social Security Institution (SGK, Turkiye)
TUB **:** Turkiye Union of Pharmacist (TEB, Turkiye)
ACC **:** Ankara Chamber of Commerce (ATO, Turkiye)
PMA **:** Pharmaceutical Manufacturers Association (IEIS, Turkiye)
OECD **:** Organization for Economic Co-operation and Development
UCCET **:** Union of Chambers and Commodity Exchanges of Turkiye(TOBB, Turkiye)
LU **:** Look Up Table

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C-DRUG: A MEDICATION USAGE CONTROL SYSTEM

SUMMARY

Nowadays, most of people do not follow their prescribed medications because of their busy life, memory problem, and laziness. In addition, patients generally forget to meet their doctors for the same reasons. Not using prescribed medications cause the recovery period to be longer or the patient fail to recover at all. Medicines have positive impacts as long as they are taken on time with exact dosage by patients. Otherwise, it has negative impact to the patients both physical and mental.

In this thesis, for the sake of a preliminary study two kinds of surveys are prepared for both doctors who write prescriptions and public who use medications in Turkey. In addition to that, these surveys are broadcasted via papers manually and also internet with the survey's links.

Under all the information and statistics that are gathered and observed from different people, and know how that is gained, an approach, A Medication Usage Control System (C-DRUG), was developed. It targeted to clear problems that we mentioned above. C-DRUG which is based on remote management technology aims to have a firm place in the middle of patient and doctor to exchange information.

As a C-DRUG scans the data which is entered by doctor, through database and send the signal to specially designed Intelligent Drug Container (IDC) to remind patient to take the prescribed medication on time. It also helps to track what medication has been taken by the patients. In other words, C-DRUG is a solution that prevents the

non-compliance. Among the other features, the system establishes a secure connection channel between doctor and patient. Last but not least C-DRUG is an inevitable solution to prevent wasting in economy, resource and etc.

In conclusion, all studies are explained in details phase by phase in this thesis. Approach and products are presented both visually and physically.

C-DRUG: İLAÇ KULLANIMI KONTROL SİSTEMİ

ÖZET

Günümüzde, insanların çoğu günlük yaşamdaki yoğunluklarından, hafiza problemlerinden ya da tembelliklerinden dolayı reçetelenmiş ilaçlarını takip edemiyorlar. Bunlara ek olarak, doktorları ile olan randevularını da aynı nedenlerle unutuyorlar. Reçetelenen ilacın zamanında kullanılmaması, tedavi sürecini uzattığı gibi, hastanın tamamen iyileşmesine de engel teşkil eder. İlaçların doğru zaman ve dozajda alınmasının olumlu etkisi vardır. Aksi durumda ise hastaya hem zihinsel hem de fiziksel olarak negatif etkisi olur.

Tez çalışması sırasında, iki çeşit anket hazırlandı. Bu anketler Türkiye'de ilaç veren ve ilaç alan taraf olan doktor ve hastalara dağıtıldı. Bu dağıtım kişilere kağıt olarak verildiği gibi, internet üzerinden anket linkleri oluşturularak ta yayınlandı.

Toplanan bilgi ve istatistikler, ayrıca insanlar üzerinde yapılan gözlemler ve kazanılan tecrübeler ışığında, C-DRUG yaklaşımı geliştirilip, tasarlandı. Bu sistemin tasarlanma amacı yukarıda anlatılan problemleri çözmeyi hedeflemekti.

Uzaktan yönetim teknolojisine sahip olan C-DRUG, doktor ve hasta arasında bilgi transferini gerçekleştirmek üzere kritik bir yere sahiptir. C-DRUG, doktor tarafindan girilen veriyi veritabanından sorgulayıp, özel olarak tasarlanan Intelligent Drug Container (IDC) cihaza sinyal göndererek, hastanın ilacını zamanında almasını sağlar. Bu sistem ayrıca, hastanın hangi ilacı aldığını da izler ve takip eder. Diğer bir deyimle, C-DRUG, reçeteye olan itaatsizliği ortadan kaldırmayı da sağlar. Tüm bu özelliklerinin yanı sıra, doktor ve hasta arasında güvenli bir iletişim kanalı kurar. Son olarak dikkat edilmesi gereken bir başka çarpıcı nokta da, ekonomi alanında, ülke kaynakları anlamında ve bunun gibi diğer unsurlar çerçevesinde, israfi önleyen vazgeçilemez bir çözümdür.

Sonuç olarak, bu çalışmaların tümü, fazlar halinde tez üzerinde detaylı bir şekilde açıklanmıştır. Yaklaşım ve ürünler görsel ve fiziksel olarak sunulmuştur.

1. INTRODUCTION

People, generally do not follow their medication because of their busy life, forgetfulness, or laziness. Not using prescribed medications cause the recovery period to be longer or the patient fail to recover at all. This slow recovery has vital effects not only on patients themselves but also on society as well. Late recovery has a permanent impact on patient both psychologically and physically. Extended recovery periods also disrupt relationships of doctors and patients. Patients start to lose their faith in their doctors, and diagnosis. In addition, due to extended recovery periods, and ineffectiveness of the medication on the symptom is interpreted by the patient as the medications have no positive affect at all. This issue is widely known as the non-adherence and makes the prescribed medication wasted. Thus, unused or wasted medication has destructive economical results for both local and global economy. When the data for the year 2011 from Social Security Institution (SSI) in Turkey, given Table 1 [1], is analyzed, the seriousness of the issue from all perspectives becomes obvious.

Table 1: Prescription Data Analysis, end of year 2011

	2008	**2009**	**2010**	**2011**	**Rate of Change**
Number of Prescriptions (K)[1]	302.412	327.001	306.461	339.617	10,82%
Invoice Amount (K, TL)	13.046.556	16.005.392	14.897.455	15.288.061	2,62%
Amount Per Receipt (TL)	43,14	48,95	48,61	45,02	-7,40%

[1] K represents a quantitative value of 1000.

As the data of the Table 1 is taken into consideration and analyzed further, in terms of the distribution of the prescription amount per receipt, the number of prescriptions, the total invoice amount, and a quantified impact on the economy can be seen in Figure 1, Figure 2, and Figure 3 respectively by years.

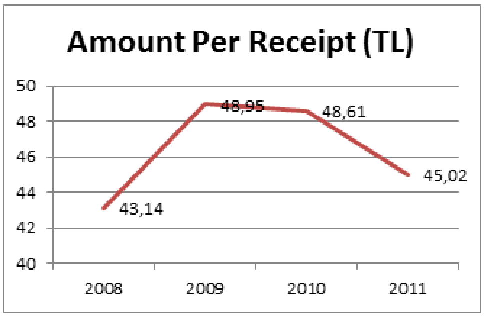

Figure 1 : Statistics of Amount Per Receipt

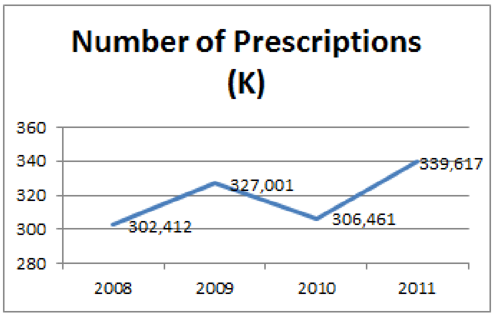

Figure 2 : Statistics of Number of Pres.

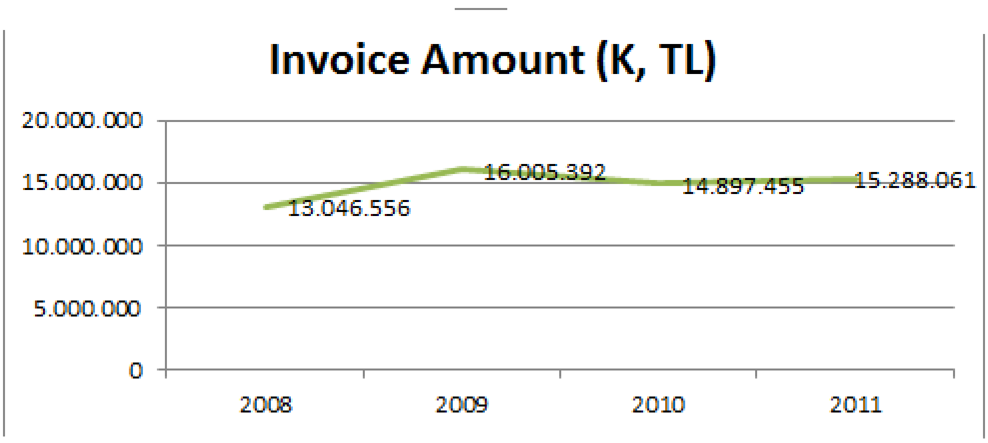

Figure 3 : Statistics of Invoice Amount

The Ministry of Health of the Republic of Turkey and General Directorate of Pharmaceuticals and Pharmacy publish a declaration about of the medication waste. In these reports, they indicated that “45/100 boxes of drugs are wasted unopened”[16]. With respect to the year 2011, the Ministry of Health of the Republic of Turkey paid 6.750.000.000 TL for wasted and unused medication [1].

This analysis report is published by not only Ministry of Health of the Republic of Turkey, but also one of the international organizations, World Health Organization (WHO) as well. This report that is analyzed for Turkey has the same parallel results with WHO which published these kind of reports for world wide.

1.1 Importance of Problem

Patients are monitored for centuries by medical personnel. The advances in technology help to improve communication and knowledge transfer between patient and doctors. The fundamental idea is to exploit the potential of the technology to enhance the quality of service by enhancing the communication between doctor and patient in terms of tracing the usage of prescribed medications in real time. Extending the medication usage time is dangerous and costly for patients. During treatment period, key point is communication and confidence between doctor and patient.

During the treatment, doctor needs to analyze prescribed medications usage frequency of patient to determine responses of patient to the treatment. Furthermore, as mentioned above, Ministry of Health of the Republic of Turkey indicates that %40 of total expenditure of Turkish Ministry of Health covers prescription expenditure [7]. According to WHO publications, all other countries have the same rate of expenditure and distribution like Turkey . This information shows that economics are facing a hazardous and important problem. Government officials, independent health facilities and medical doctors are aware of the problem. They follow up any possible solutions to remove the problem or minimize its effects.

At the end of 2012, SSI publishes a new manual and operational solution. They create a new job to solve solely this problem. This new job’s name is Drug Inspectors. Drug Inspectors will go to every patient’s home and they will gather information about number of unused medication they have. When related reports and statistics are evaluated, it is obvious that how much damage it causes. It dramatically effects to government and its’ people [2].

In this proposal, for the sake of a preliminary study two kinds of surveys are prepared for both doctors who write prescriptions and public who use medications in Turkey. In addition to that, these surveys are broadcasted via papers manually and also internet which contains Facebook, twitter and linkedIn with the survey's links. Surveys for doctors, surveys for public and their electronic links are presented in Appendixes part of the proposal.

Furthermore, 100 doctors and 1000 persons who use medications joined the surveys. This participation provides critical data to proposal. The completed data analysis on collected information from doctors is presented in Table 2. In Table 2, only 5 sample questions are selected by its importance from the doctors' survey. The table has 4 fields which are Question, Response, Response Symbol, and Highest Rates of Related Responses. Response field consists of the most preferred choices form the survey, and the rate of the selected choice is presented with Highest Rates of Related Responses field.

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Table 2 : Some questions and responses of Survey for doctor[2]

Nr.	Question	Response	Response Symbol	Response Rates
1	*How many prescriptions do you fill in a day?*	50-99	**A**	52%
2	*How many patients would contact you again, after examination?*	%5 - %19	**B**	92%
3	*All prescribed medications that you filled, is used by patient?*	No Idea	**C**	90%
4	*How closely you can follow the patient if the patient applies prescribed medication?*	Cannot follow	**D**	57%
5	*Do all patients follow the schedules that you fill in the prescriptions?*	Irregular medication use[3]	**E**	88%

[2] Highest rated responses in Survey included in table.
[3] Patients take the medication but not at the scheduled time.

In Figure 4, the highest rate of the responses from the survey is presented. In order to locate responses clearly in Figure 4, the Response Symbol field in Table 2 is used for abbreviation.

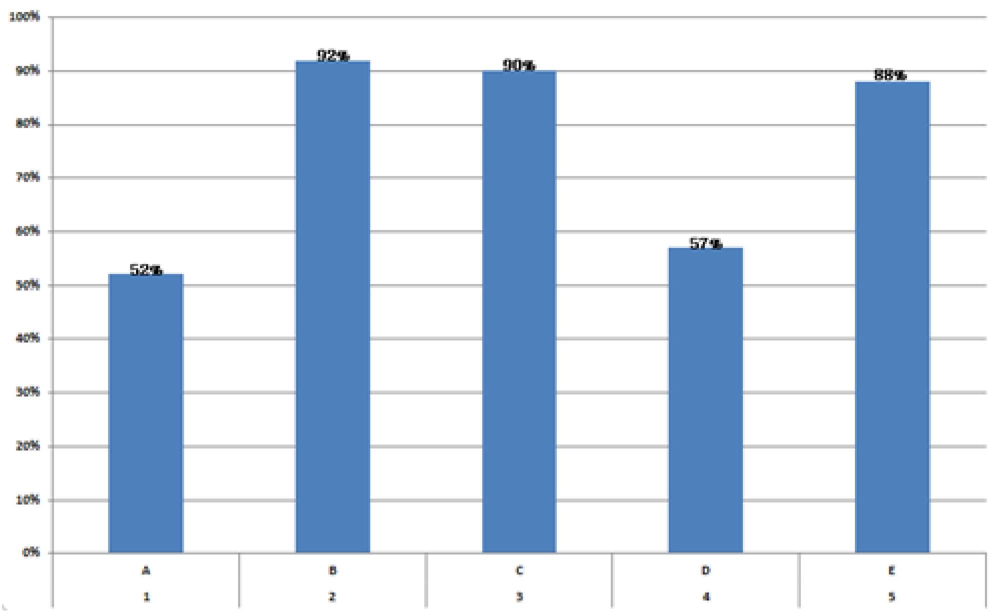

Figure 4 : Graph of response rates related of questions in survey for doctors.

The data analysis of collected information on persons/patients is given in Table 3. In Table 3, only 9 sample questions are selected by its importance from the patients' survey. The table has the same fields used in the Table 2. Namely, they are Question, Response, Response Symbol, and Highest Rates of Related Responses. Response field are consist of the most preferred choices form the survey, and the rate of the selected choice is presented with Highest Rates of Related Responses field.

Table 3 : Some questions and responses of Survey for person[4]

Nr.	Question	Response	Response Symbol	Responses Rate
1	*How many unused medication do you have?*	5-20	**A**	73%
2	*Do you take medication without going to health care center or doctor?*	Rarely	**B**	54%
3	*How did you take medication without any prescription?*	Take same medication with prescription earlier	**C**	87%
4	*Do you exactly follow the schedules when you get prescriptions?*	Take the medication but not at the scheduled time	**D**	77%
5	*Do you consume all prescribed medications that you get for your treatment?*	Do not take medication when i feel better	**E**	68%
6	*What do you do with your usused medications?*	Keep in medicine cabinet for future	**F**	56%
7	*How do you remind the period of medication to yourself for taking them?*	Trust my memory	**G**	95%
8	*Do you go to your doctor again for your status when you take all medication that you get?*	No, do not go there again	**H**	71%
9	*Do you think that your doctor follow your adherence of your prescription?*	I provide information however he does not take any note about my usage	**I**	88%

In Figure 5, the highest rate of the responses from the survey is presented. In order to locate responses clearly in Figure 4, the Response Symbol field in Table 2 is used for abbreviation. The levels of bars in both Figure 4 and Figure 5 signify the importance and the necessity of the approach presented in the proposal.

[4] Highest rated responses in Survey included in table.

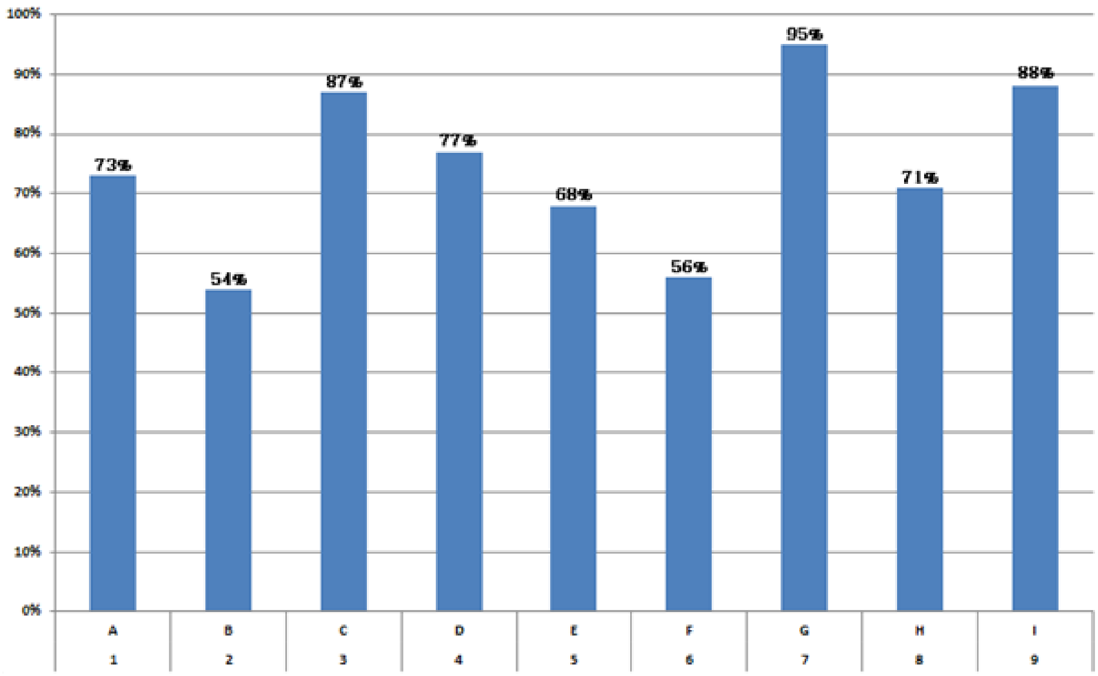

Figure 5 : Graph of response rates related of questions in survey for person.

1.2 Proposed Approach

Most of people do not follow their prescribed medications because of their busy life, memory problem, and laziness. In addition, patients generally forget to meet their doctors for the same reasons. These are vitally important issues for patients especially patients with chronic diseases. At this point, A Medication Usage Control System (C-DRUG) which will be based on remote management technology aims to have a firm place in the middle of patient and doctor to exchange information. As a C-DRUG will scan the data which entered by doctor, through database and send the signal to specially designed Intelligent Drug Container (IDC) to remind patient to take the prescribed medication on time. It will also help to track what medication has been taken by the patients.

In other words, C-DRUG will be a solution that prevents the non-compliance. Among the other features, the system will establish a secure connection channel between doctor and patient. Thus, patient information would not be able to seen by anyone except his doctor or another authorized user. Therefore, within the scope of the proposal, the following objectives are presented for the system shown in Figure 10.

Objective 1. Development of the Hospital Record System (HRS)

- **Objective 1.1,** Development of Patient Information System (PIS)
- **Objective 1.2.** Development of the Patient Tracking System (PTS)
- **Objective 1.3.** Development of the Notification System (NS)

Objective 2. Development of Intelligent Drug Container (IDC)

Objective 3. Development of Mobile Tracking System (MTS)

The word introduced here is an elaborated extension of the work called Remote Patient Monitoring System [23].

2. RELATED LITERATURE

Nowadays, healthcare personnel are provided with programs related to adherence problems. These programs focus on some specific areas such as simplifying dosage regiments and delivering, educating the patient, communicating with the patient, and modifying the patients' behavior. Programs that are influential on increasing adherence are separated into two groups. These groups are Direct Methods [23] and Indirect Methods [23] as shown in Figure 6 in detail.

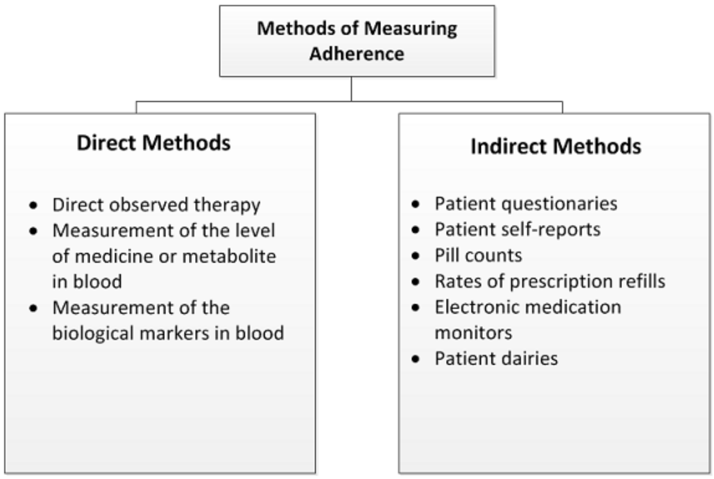

Figure 6 : Methods for Measuring Adherence [23]

2.1 Direct Methods

Direct methods are generally expensive and require continuous visit to doctor's office. Some of the examples of these methods are direct observed therapy, measurement of the level of medicine or metabolite in blood, measurement of the biological markers in blood [23]. Usage of these methods is not applicable in the long term due to the presence of the patient in clinic or hospital and also expenses.

2.2 Indirect Methods

Indirect methods are very practical when compared to direct methods, in terms of not only for easy implementation by patient but also low costs as well. Some of the indirect methods are patient questionnaires, patient self-reports, pill counts, rates of prescription refills, electronic medication monitors, and patient diaries [23]. Despite the increasing frequency to doctor, patients can easily provide wrong and missing information to their doctor due to forgetfulness.

One can trace the use of patient diaries since they provide detailed information about medication usage. However, to provide this information, the patient has to take note about each medication usage. This process is generally not useful because of the manual processes. At the end of the period, manual processes cause deficiency in information. Thus, doctors may get missing information from patients.

Pill counts, rates of prescription and electronic medication monitors are objective, precise, and quantifiable methods. They are easy to be implemented because these methods requires less input from patient and doctors to get information about medicine usage.

Therefore, companies provide different solutions to the patients to overcome non-adherence problem. Some of these solutions are automated medication helpers which remind patients to take their medication on time. There are some kinds of solutions in the market at the moment in order to prevent the exchange of incomplete, wrong, and missing data between doctors and the patients.

These solutions can be divided into three categories. These categories are Automated Pill Dispensers, Pill Organizers, and Medication Reminders as shown in Figure 7, Figure 8, and Figure 9, respectively.

Figure 7 : Sample Images of Automated Pill Dispensers [9].

Figure 8 : Sample Images of Pill Organizers [10].

Figure 9 : Sample Images of Medication Reminders [10].

Regardless of the type, each one offers a partial solution to the problem. More specifically, they only remind the patient who may suffer from an impaired memory to take the prescribed medication. Although, some versions of these solutions are capable of sending messages via e-mail or SMS to the patient, companion or caretaker, but the most of the products only warn the patient and dispense the medication.

Moreover, all of the direct and indirect methods listed in above do not interact with patient, companion and caretaker. In addition to that, they do not provide any information about habits of the patient's medication usage. Another disadvantage of these kinds of products related within the usage is, not only users have to know technical and operational information about usage of the product but also they must have technical skill to apply it. The user must set the alarm manually for taking each dosage of the prescribed medication. Last but not least, it needs to be done daily.

3. TECHNOLOGY BASED MEDICATION USAGE CONTROL SYSTEM

C-DRUG included all the current solutions and technologies and also complement their deficiencies. This research is intended to provide solutions for people who need long-term treatment to reduce significantly the difficulties of living with drugs. Besides, it is to provide amount of the drug taking your treatment deemed necessary, instead of the amount needed to be taken outside the packages of drugs. In addition to this, both the patient himself/herself as well as the doctor monitored the pharmaceutical use for the treatment electronically. It allows you to make an inquiry per prescription of backward dates concerning the patients.

Busy work schedule and forgetfulness influences people's drug use negatively. As a result, the healing process extends in a terrible rate and that causes a deep impact on individual and as well as society. In addition, extended recovery affects humans' psychology. People are losing their trust in doctors and drugs, because they are starting to think that treatment with prescribed drugs or the diagnosis itself is wrong.

The drugs that are expired, not taken on time or not taken at all are wasted drugs. Waste causes economic harm to the individual itself and the government agencies or private health institution. This makes individuals spending a large portion of one of the most important expense of the state in the health sector by the garbage disposal indirectly. In the countries that are increasing the number of insured citizens day by day causes these costs increasing exponentially. This limits the state budget that would be allocated for other institutions outside of the health sector. It also directly affects the citizen himself.

This research sits exactly on the problem of non-adherence that is encountered in different parts of our society, the so-called health sector. With the help of technology, researchers aim to minimize the economic and social impact of this problem. Therefore, to follow the medication usage habit without creating an overload of the patient's memory is to design an integrated monitoring system to extend the necessary help for all parties involved, including the diagnostic center (e.g., doctor's office) interested in tracking the treatment plan relevant to drug usage.

Last but not least, C-DRUG recognized that the medication sold in the market would trigger which other medications would be used after. Moreover, C-DRUG was able to determine the intersection points of illnesses and their medications. Consequently, C-DRUG helped to collect crucial data about effects of the different medications on patients.

3.1 Design Issue

C-DRUG was proposed to prevent non-compliance problems. C-DRUG is a centralized system consists of four main components which are Health Record System *(HRS)*, Patient Information System *(PIS)*, Intelligent Drug Container *(IDC)* and Mobile Tracking System *(MTS)*. PIS has also two sub components which are Patient Tracking System *(PTS)* and Notification System *(NS)*. All patient related information is stored on PIS Server through HRS. HRS is a system shared with different hospitals, clinics and pharmacy. This structure provides an information sharing platform between patient service providers on PIS Server.

The doctors from different hospitals, clinics and pharmacy are able to monitor and modify the same patient’s information. IDC is the hardware system that provides drug to the patients. IDC gives drugs to patients, monitors the drug usage and feedback this information to the patient’s related doctors. The last main component is MTS. This is for patients’ tracking their health status and drug scheduling alerts.

The C-DRUG System is developed by using tools and the environment listed in Table 4. Generally, Microsoft technologies were used to develop these applications. Development language was web based Microsoft ASPX extended with C#. Database of the system is Oracle MySql 5.2. Net framework 4.0 took place in the basis of general development approach.

Table 4 : Inventory List of C-DRUGfor person

Development Language	Microsoft ASPX based on C#
Database	Oracle MySQL 5.2
Frameworks and Libraries	Microsoft .Net Framework 3.5
Helper Development Languages	HTML 5.x, JQuery - AJAX, JavaScript, CSS3
Development IDE	Microsoft Visual Studio 2010
Integration Tools	EntityFramework
Database Modeling and Diagram	SQL Power Architect, Microsoft Visual Studio 2010
Work Flows	Microsoft Visio 2010
Image Design	Adobe Photoshop
Animation	HTML 5.x

Additionally, HTML 5.x, JQuery – AJAX, Javascript, CSS3 and Adobe Photoshop technologies were used to support development for graphical user interface phase. Microsoft Visual Studio 2010 was main IDE to develop applications. MS Visual Studio and SQL Power Architect were used for database development and integration. Besides these, MS Visio was used for designing workflows and use cases.

3.1.1 Architectural Design

The C-DRUG was designed to be solution that would solve non-adherence by monitoring medication usage and sending notifications constantly to patients in a secured manner. Although the C-DRUG solution has some of the same functions the current solutions possess, the most of its functions are new and have not proposed by the current solution such as IDC, NS, and etc. yet.

The C-DRUG is a centralized system that contains three main components, HRS, IDC and MTS. HRS that sit upon the center of the C-DRUG that contains all the record of the patient, doctors, healthcare centers, drugs etc that has three sub-system. Besides recording information, HRS manages the notification and monitors the patient information.

IDC is a hardware system that created with drug cartridges and used by managing and monitoring patient's medication usage and informing the patient. Lastly, MTS is designed as a mobile application that informs the patient's medication usage, treatment status, medication schedule, remaining drug amount, etc.

In Figure 10, the general structure outline of the C-DRUG and its connections to the environments can be seen such that HRS is the core system of the C-DRUG. HRS provides the Graphical User Interface (GUI) and database of C-DRUG. The web-based GUI of C-DRUG is designed to be used by Healthcare Center and pharmacy personnel. By using GUI, doctors, nurses and other personnel's of any Healthcare Center can create and manage patient records regarding their illnesses, treatment methods and prescriptions. Also, medication usages and treatment period of a patient could be monitored by the related Healthcare personnel.

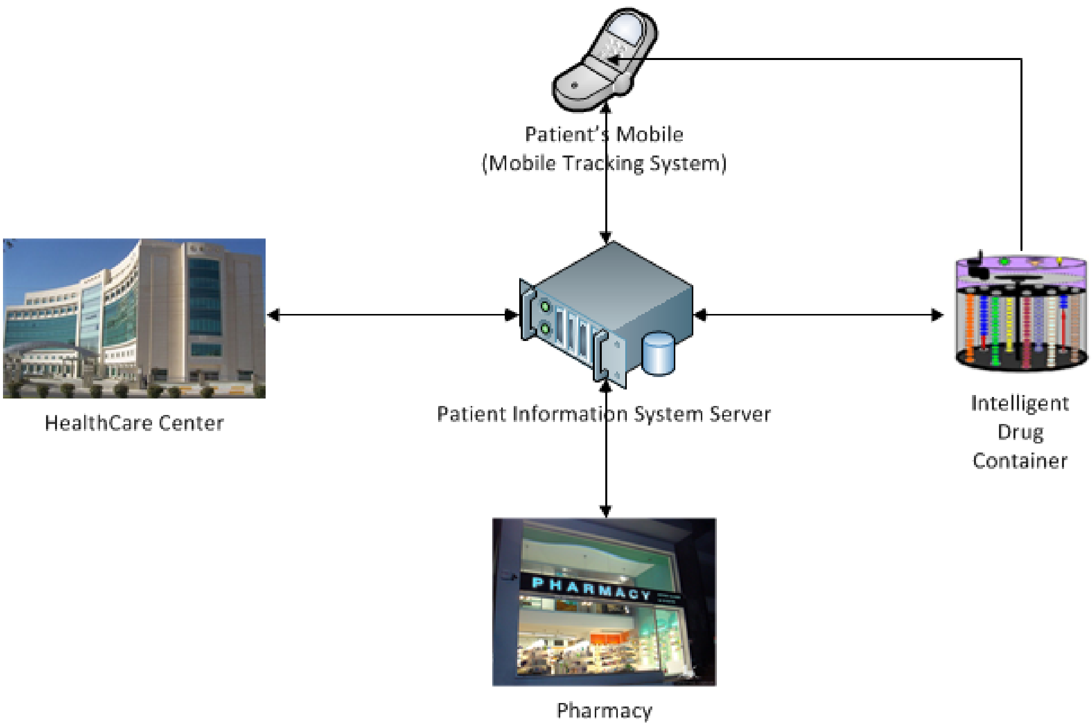

Figure 10 : Interaction of Components in Medication Usage Control System

After prescriptions are created for a patient, that patient would go to a pharmacy recorded in C-DRUG and pharmacy personnel would prepare the patients' medications. In the process of the medication preparation, C-DRUG generates QR Codes for every kind of medication listed in the prescription by using system-recorded prescription id, medication unique code and the amount of the regarding medication given. These QR Codes also can be recorded in C-DRUG to be used by patients IDC.

The tubes taken from the pharmacy would be inserted in the patient's IDC and IDC would use its one of the available connection methods and get scheduling information of the patient's medication by matching QR codes. This information would be taken on a secure-encrypted connection line.

C-DRUG also provides general monitoring information regarding patient's treatment periods. This monitoring information could be seen by related doctors from C-DRUG GUI and also by patients himself/herself from MTS. MTS would connect directly to the services provided by HRS for patients.

The Figure 11 puts forth integration of C-DRUG's components such as hardware and channels. C-DRUG has its own database server. All records are kept in that database. C-DRUG has also another server. Beside that information, web services and automated server based application run that server.

Moreover, C-DRUG has e-mail and mobile services, thus it has directly crucial integration with email server and mobile operator environment. It uses email server to send email. Also, it uses SMS Gateway to send SMS via Mobile Operator Environment and to receive SMS from outside via Mobile Operator Environment. SMS features are handled by contracted mobile provider.

In addition to them, HRS and MTS which are components of C-DRUG, are published via secure Internet to its user from another web server in that scope. In the case of publishing this application to the Internet, Mobile Phone, PDA, Laptop, Personel Computer or Smart Tv, furthermore IDC access to the C-DRUG via various connection layers such as Mobile Gateway (EDGE, 3G,4G), wired and wireless.

Consequently, deployment and distributing of C-DRUG are effortless with that architecture. One of the advantages of that is, to minimum complexity and dependency and also maximum productivity. Last but not least, system is ready to separate easily whenever necessary.

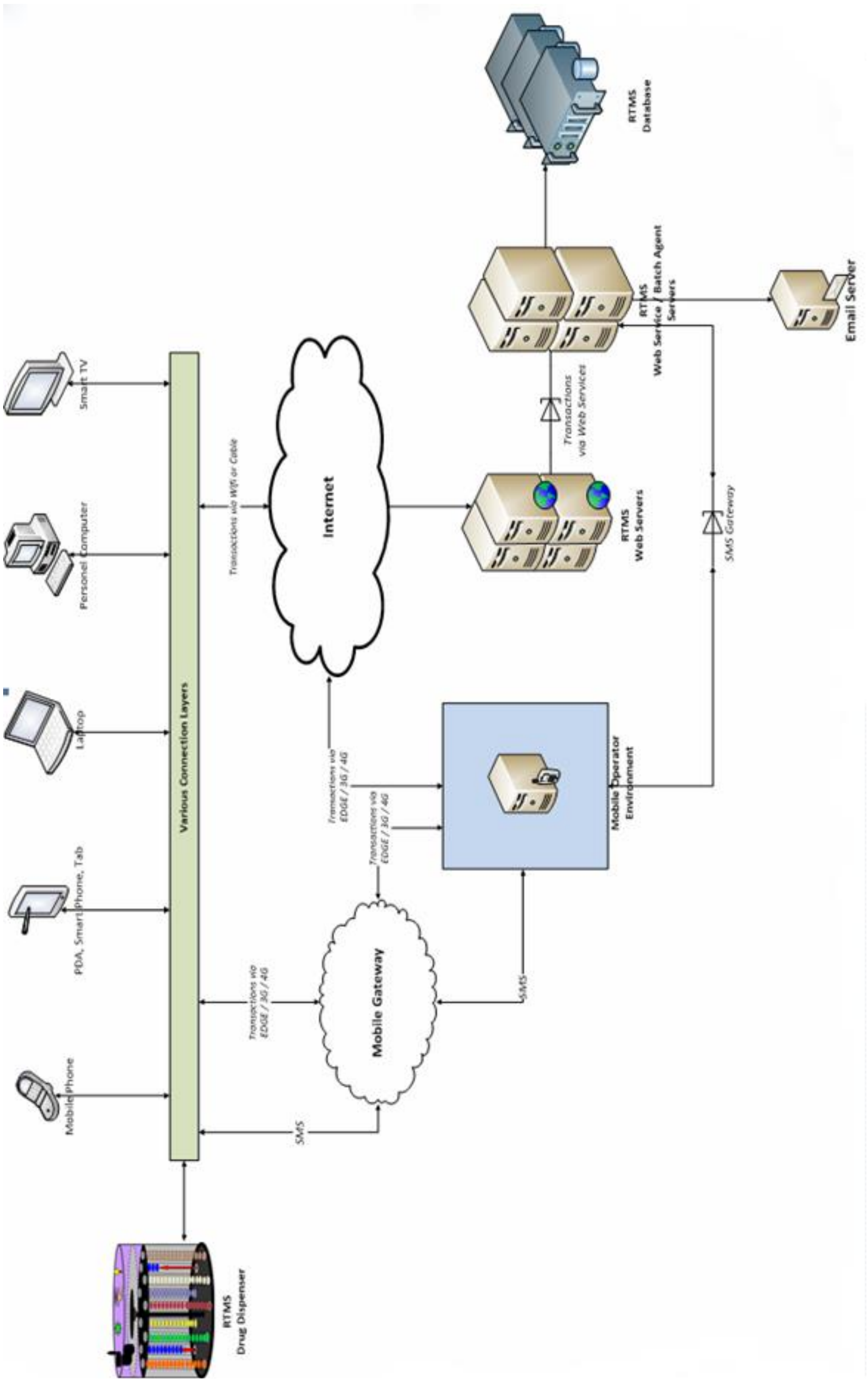

Figure 11 : Structural design of C-DRUG with all hardware and related channels

3.1.1.1 HRS

HRS is the center system of the three main components of the C-DRUG. HRS consists of three subsystems that are PIS, NS and PTS. Figure 12 shows the details of the HRS, its sub-components and the interactions of its environment as the use case diagram of the HRS. Also in Figure 13, the outline structure of the HRS is shown abstractly. PIS is the database and the user-interfaced of HRS that contains patients records, doctors remarks, medication usage, medication amounts, hospital records, pharmacy records, HRS interface users, notification records, etc. and HRS interface used by doctors, personnel, pharmacy, etc. to manage the C-DRUG.

NS is notification system that used to update the related patients' records and inform them about their medication usage by using the available methods such as SMS, e-mail, etc. given by the IDC system. NS is designed as a software service and does not have a user-interface. The communication between the NS and IDC system is a secure 128-bit SSL encrypted communication.

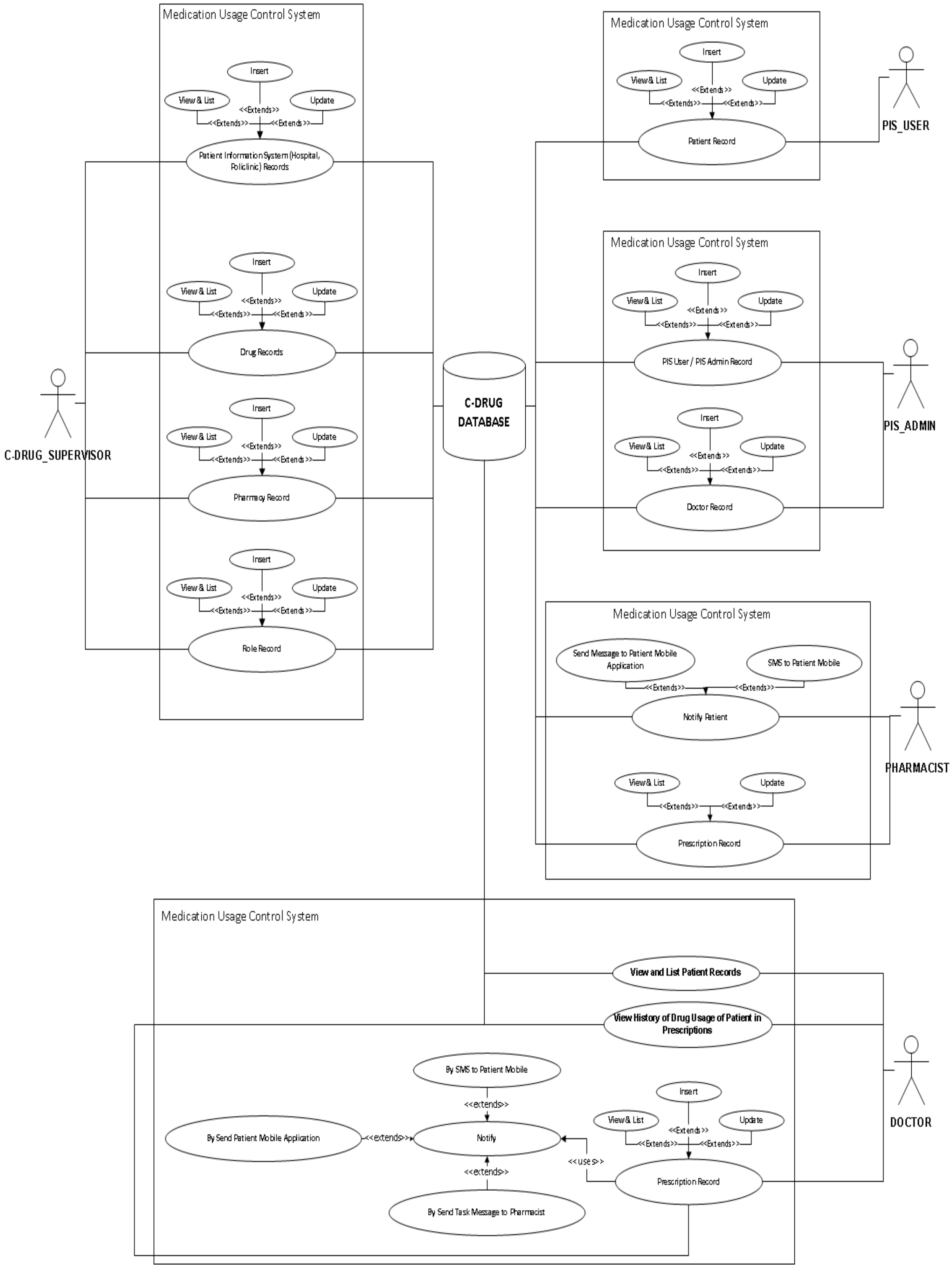

Figure 12 : Use-Case Diagram of HRS

The last sub-component of the HRS is PTS. PTS was designed as a reporting system for MTS and HRS user-interface. By using PTS, patient history, medication usage rates, patient status, medication schedule, remaining treatment info, etc. information are controlled regularly by patient himself/herself or the related doctor.

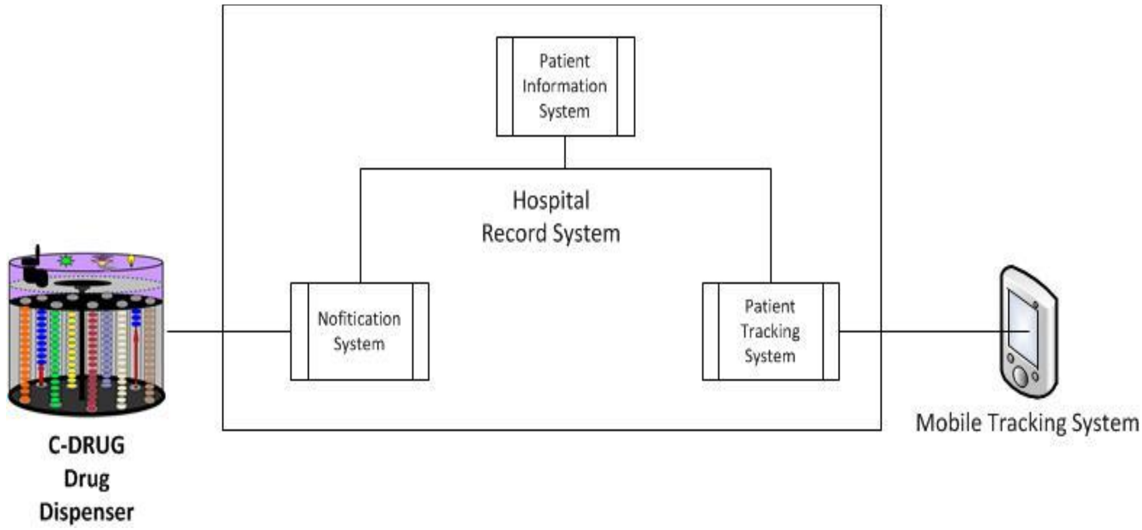

Figure 13 : HRS and its own sub components

3.1.1.2 IDC

IDC is the hardware component of the C-DRUG that used for maintaining patients' drug usage by informing them. IDC system contacts the NS sub-system of the HRS component by a secure line. In this connection, IDC system use any available method given to it such as cabled network, wireless network or Edge/3G/4G networks to inquiry the related information about medication by using QR Code on the medication tubes. QR Code is generated by using the prescription id, drug id and amount of drugs while getting the medication tubes from pharmacy personnel.

In Figure 14, the general functions and the properties of the IDC is exposed as the use case of the IDC. IDC manages and monitors medication usage on the designated schedules and inform the patients to take their ready medication from the Medication Chamber.

The results of these operations will be always updated on HRS by using NS subsystem either successful or failure. Also, IDC has its own notification systems that is voice alarm, notification led, and sending messages In case of a failure of a medication take out, IDC System automatically re-insert the medication its own tank by using Control Shaft and re-order the medication take out order by updating its own memory by using mobile phone application from users.

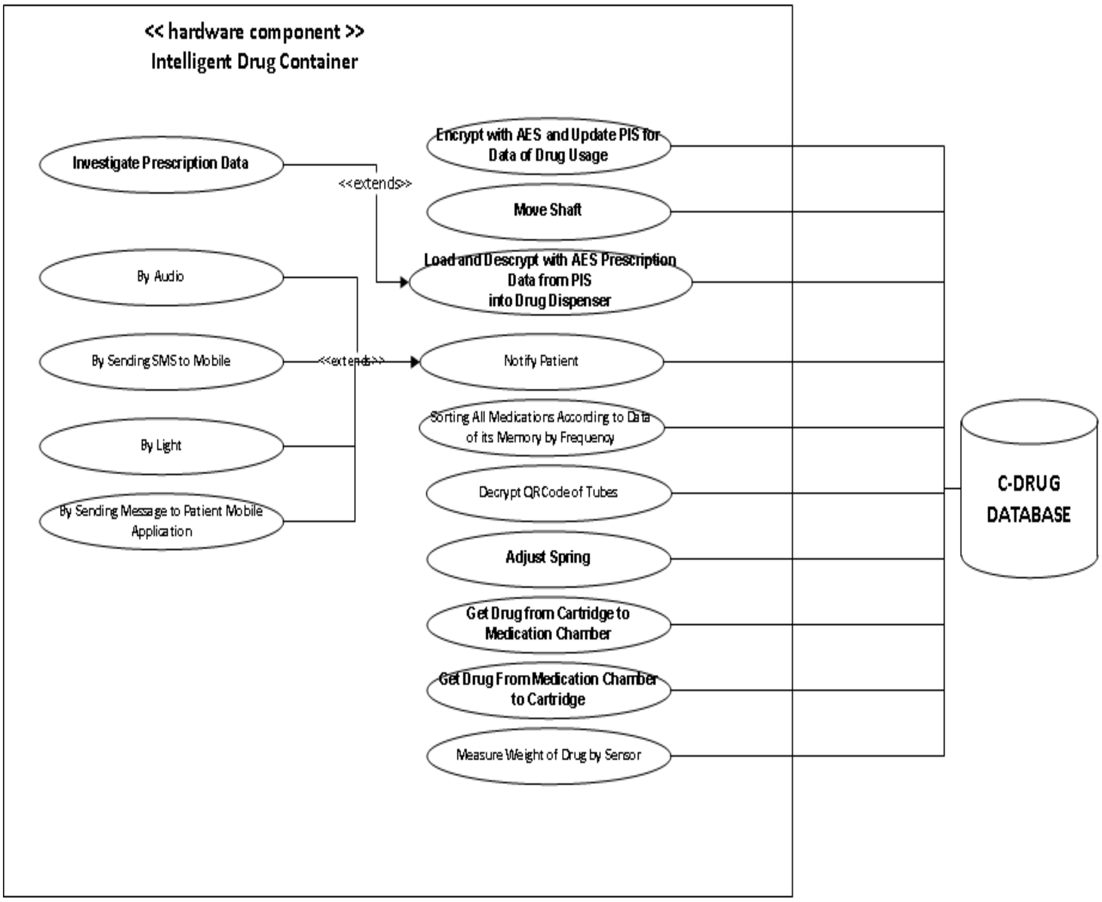

Figure 14 : Use Case Diagram of IDC

Pseudo design of IDC is shown in Figure 15. It includes the parts which are Medication Chamber, Cellular Network(EDGE/3G/4G) embedded in SIM Card, LAN (Wired) and Wireless Adapter, Audio Notification, Light Notification, Control Shaft, Drug Cartridges, Adjust Spring, Weight Sensor, and memory chip.

Medication Chamber is used for holding medication which is taken out from IDC. Cellular Network (EDGE/3G/4G) embedded in SIM Card is used as one of the connection establishing methods with HRS to synchronize medication schedules and medication usage. LAN (Wired) and Wireless Adapter are alternative connection methods to synchronize data with HRS. Audio Notification and Light Notification are designed to alert patient directly on device. But message notification to the mobile is done via NS.

Furthermore, Control Shaft, Drug Cartridges, Adjust Spring, and Weight Sensor are used for managing medication inside IDC. Lastly, Memory Chip is a key point to make IDC as an intelligent device. Also, it coordinates parts of the device and provide the connection to HRS via web services programmatically.

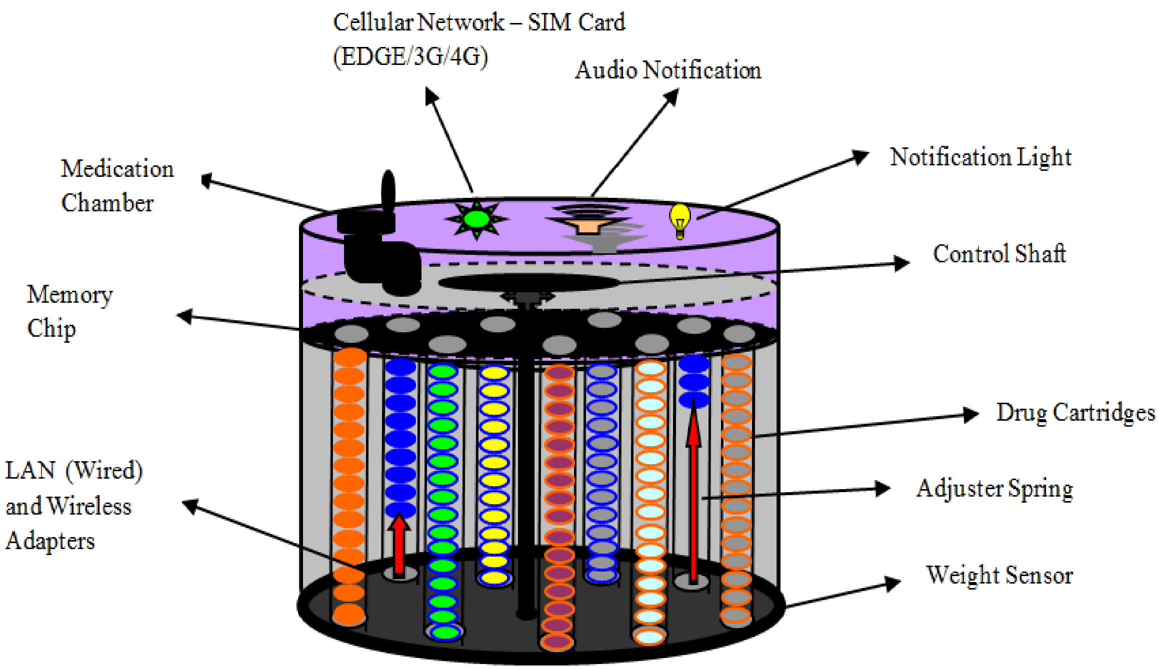

Figure 15 : Illustration of IDC and its own properties

3.1.1.3 MTS

MTS is designed as a mobile application that helps the patient track its own or a family members' treatment status by using pre-defined reports such as medication usage, remaining medication amount, hospital records, doctor remarks, patient history etc. shown in Figure 16.

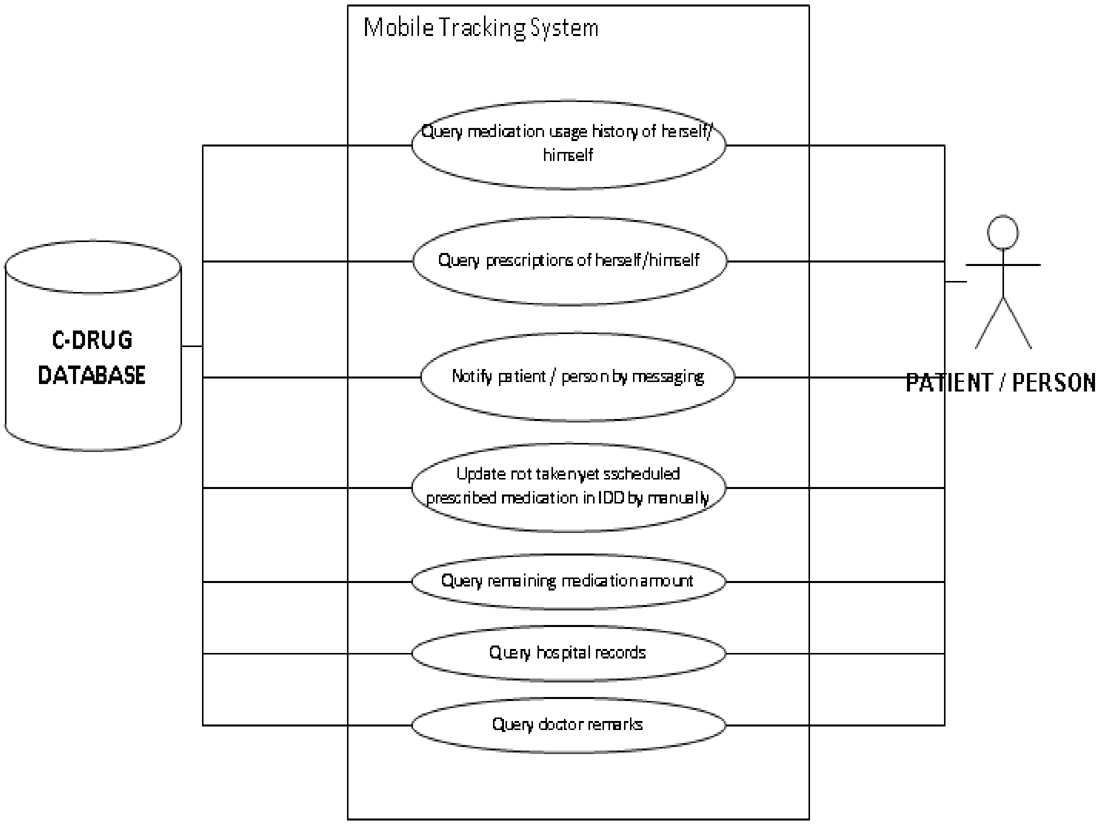

Figure 16 : Use case of MTS

Furthermore, patient or person has an update option to reschedule medication for untaken prescribed medication which is received back to IDC. It is designed as tracking system by using PTS sub-system of the HRS.

3.1.2 Functional Design

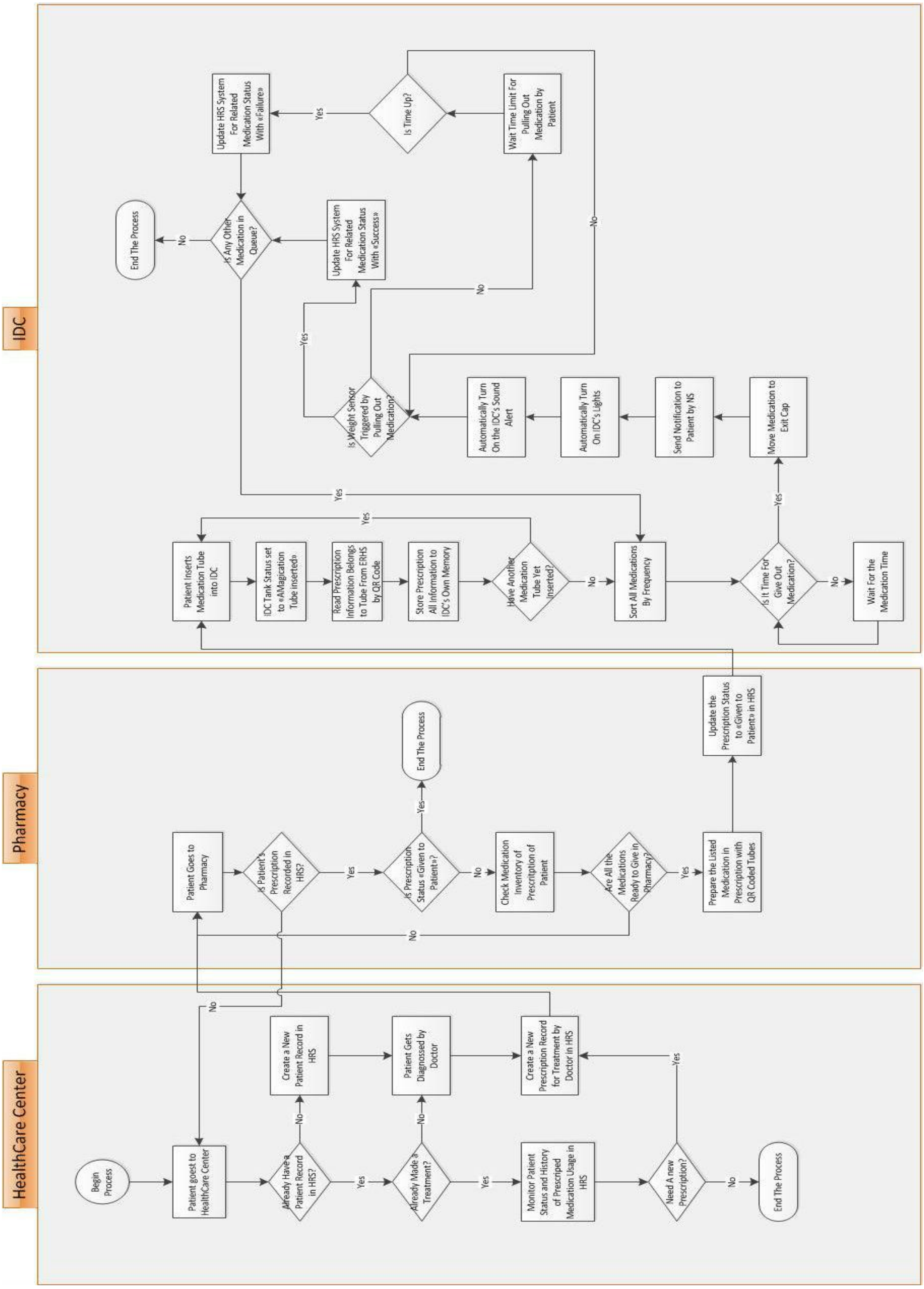

Figure 17 : General patient, doctor and drug dispenser relationship scenario in C-DRUG

For the statement above, the flow of recommended C-DRUG solution as shown in Figure 17 is expected to be the following; when a patient gets ill, the patient would go to a hospital or a clinic to get a treatment. In the Healthcare Center, the patient firstly is checked that he/she already has a record on HRS. If it is the first time of the patient coming to a Healthcare Center, personnel on duty would create a new record for patient in HRS by using patient basic personal information such as name, surname, ID number, date of birth etc.

Therefore, if the patient already has a record in the system, the patient would be check for if he/she comes for re-examination. After the creation of the patient record or check and see that is a new examination, the patient would be directed to the related doctor by personnel on duty to get diagnosis. If the patient comes to the Healthcare Center to get re-examined, the patient would be directed to his/her doctor who is responsible. Then, the doctor would re-examine the patient and monitor the status of the patient and the history of the prescribed drugs usage by using the data and report in PTS subsystem. After the re-examination, if the doctor does not deem necessary, the doctor encourages the patient to continue the usage of prescribed drugs and the treatment like before. If it is the first time for the patients coming the Healthcare Center for his/her illness, the patient would be examined by the related doctor.

After the first-time examination or re-examination, if the doctor deem necessary, he/she would prescribe the drugs required to treat the illness of the patient. The usage frequency and the amount of drugs would be recorded to the HRS by doctor. In these drug records, the produced drug codes, detailed names are used for drug identification.

Afterwards, the doctor would guide his/her patient to a pharmacy nearby or the patient could choose any pharmacy included in HRS. When the patient is gone to the pharmacy, the pharmacy personnel would check the prescription and its content by using Prescription ID given by the doctor. If the prescription is not recorded in HRS or its status is not "Given to Patient", the pharmacy personnel would not give the intended drugs and urges the patient to contact to the healthcare center.

In case, it is a valid and correct prescription, the pharmacy personnel would control the inventory for the patient's prescription. If the drugs requested are not enlisted in the inventory, the pharmacy personnel send the patient to another pharmacy nearby. If the drugs requested are enlisted in the inventory, the personnel prepare them to deliver the patient. These drugs would be prepared as in tubes and only by the required amount. In the process of preparation, unique QR Code are generated for drug tubes by using prescription id and drug code in HRS and stick these QR Codes to the respective tubes to differentiate. After the preparation of drugs and deliver it to the patient, the personnel would update the prescription status to "Given to Patient" in HRS and prevents it given in another pharmacy. Then, the patient would go to his/her personal IDC to insert drug tubes in and start to use the drugs.

Afterwards, the operation would run automatically by IDC system. To summarize the flow of operation after the drug tubes inserted, IDC system would start the operation by setting its respective status of tank used by drug tubes to the "Medication Tube Inserted" and lit its led. And then, IDC system would read the QR Code on the drug tubes and store these QR Codes to its system. After that, IDC system would try to connect to PIS subsystem of HRS by using an available connection method from cabled internet, wireless internet or 3G internets in order. After the connection is established, IDC system would read all information regarding the drug tube such as amount of drugs, frequency and time of its usage, etc. by using QC Code that are created by using prescription id and drug code. Furthermore, this information is stored in the IDC system and if there is more than one drug cube, the operation would be repeated for each and stored in the IDC system.

As soon as the drug cubes are inserted and their information is inquired and stored to the IDC system, IDC system orders all drugs to give them out according to the frequency and time information of the drug tube comparing with the current time.

After the ordering operation, the IDC system enters in waiting state. In this state, IDC system uses the system time, check and compare it to the first scheduled drug to take it out. At the scheduled time to take the drug out, IDC system would move its control shaft and move the tank that has the scheduled drug in to its Medication Chamber.

After the completion of the moving process, IDC system would put required amount of the drug to its Medication Chamber and change its “In Medication Chamber”. In this state, IDC system would send text notifications such as SMS or E-Mail by using NS subsystem in order to inform the patient. Besides the text notifications, IDC system also would use sound alerts and led lightings to inform the patient.

The Medication Chamber of IDC System has a weight sensor and a time sensor together. While the moved out drug waited on the Medication Chamber, IDC system would check constantly its weight sensor if the sensor is triggered by pulling out the drug and wait for the time configured in the system previously. If the drug would not be pulled out by the patient in the time, IDC system would update HRS for related drug by using QR Code of the drug tube and set the drug status to “Failure”. While updating drug status in the HRS, IDC system move the required drug to its predetermined tank and lit tank’s led red to show its failure state.

In the case of the weight sensor of the IDC System is triggered by the patient by removing the drug from the Medication Chamber in the pre-configured time, IDC System would update the drug status on the Medication Chamber to the “Success” in the ERHS by using the QR Code on the related tube. Besides the status, IDC System also would decrease the remaining amount of the related by the taken amount. Then, IDC System would change the related tanks led to green to show its success.

After these operations are finished, IDC system would control if there is any other drug is waiting for the Medication Chamber. If there is, IDC system would repeat the operation for the other drug by starting to move tank to the Medication Chamber. If there is not, IDC System would re-order the drug tank by comparing drugs’ scheduled time and the current time.

In the flow above, it has been tried to summarize briefly the solution of drug wasting by using the C-DRUG. However, the text below would explain the inner working of the RMTS and its main component in more detail.

3.2 Implementation Issue

C-DRUG has a database layer, a web service layer, a graphical user interface layer, and last but not least, an intelligent drug dispenser layer. Actually, the drug dispenser is represented as an html5 based animated simulation in coding of thesis components although it will be a powerful and a useful physically device.

3.2.1 Database Implementation

Initial step of development C-DRUG was establishing a database to store data. Oracle MySql database tool was selected for this project.

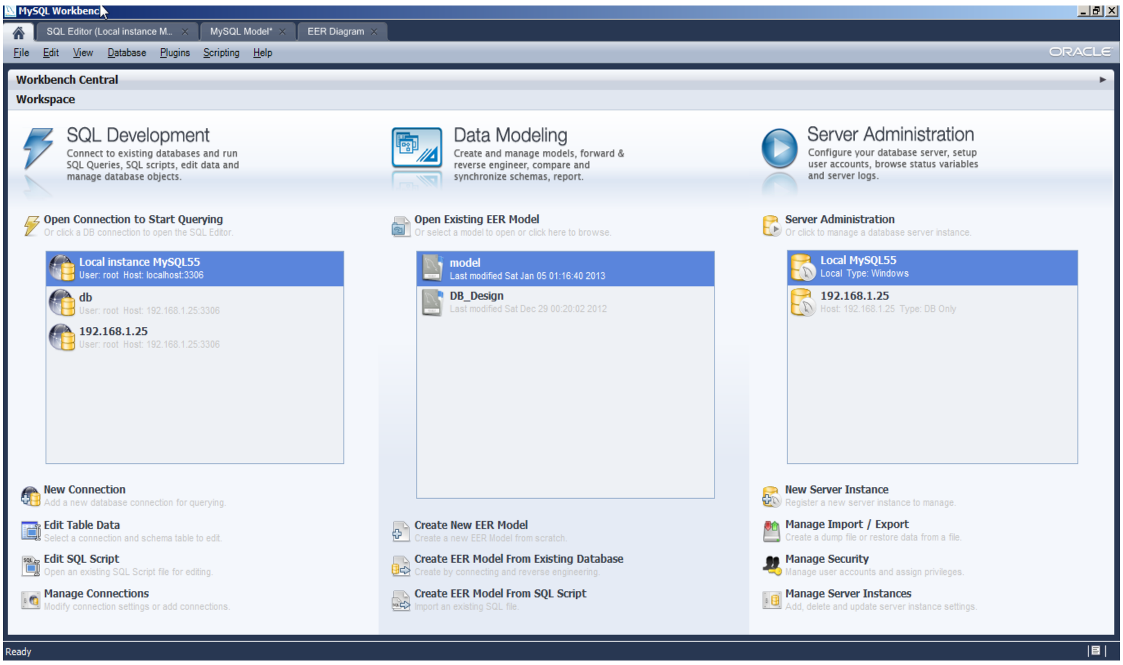

Figure 18 : User Interface of Oracle MySql

The Entity-Relationships Diagram of C-DRUG, shown in Figure 18, is designed as generic and easily updateable if deemed necessary. Also, the database of the C-DRUG is designed to contain any information about the patients, doctors, patient's prescriptions, its drugs, the medication usage information, healthcare information etc. Below is explained the entities of the database in detail.

USER: This entity is designed for containing information of C-DRUG's basic users such as doctors, nurses, Healthcare personnel, pharmacy personnel etc.

USER_PHONE: This entity is a generic table for containing telephone information of patients, doctors and related personnel.

ROLE: This entity contains differentiate group information between users as admins, doctors, nurses, related personnel etc.

LU_MEMBER_STATUS: This entity contains the pre-defined lookup information of the users' status in C-DRUG.

PATIENT: This entity contains basic information of a patient in C-DRUG such as name, surname, date of birth, state, Social Security Number, etc.

PATIENT_INFORMATION_CENTER: This entity generally contains information of patient and doctor related institutions such as hospitals, clinics, pharmacy etc.

LU_CENTER_CATEGORY: This entity contains group type list of the patient information center.

STATE: This entity contains the list of the all states of the all cities such as in the Turkey at the moment.

CITY: This entity contains the list of the all cities such as in the Turkey with their Traffic Ids are their unique Ids at the moment.

COUNTRY: This entity contains the list of the known countries.

DRUG: This entity is designed to contain of generic drug information that would be used. The drug lists is planning to be imported from a prior system such as SSI in Turkey.

DRUG_CATEGORY: This entity contains the category information of the drugs belonging to.

PRESCRIPTION: This entity contains the all prescription information that prepared by the doctor to be used for the patient treatment.

LU_PRESCRIPTION_STATUS: This entity contains the statuses of a prescription pre-defined by C-DRUG admins.

PRESCRIPTION_DRUG: This entity is designed to contain the schedule information, medication usage amount, etc. for all drugs of a prescription one by one.

PRESCROPTION_DRUG_SCHEDULE: This entity is to contain detailed schedule information a prescription drug used by the patient. This information is entered and updated by doctors.

C-DRUG_ACTIVITY: This entity is designed to contain information of the activities of the IDC System such as drug taken successfully, drug not taken in designed time interval etc. and the related notification for these activities.

NOTIFICATION: This entity contains the C-DRUG activity notification done by the IDC System to inform the patient information in detail such as notification method, notification reason, notification time etc.

LU_NOTIFICATION_CHANNEL: This is a list that contains the notification method such as SMS, E-Mail, voice, etc.

ERROR_CODE: This entity is a C-DRUG that contains generic system error codes and errors.

AUDIT_LOG: This entity contains all trace logs of the operation done by the C-DRUG users in case of a need for retracing a prior operation.

Figure 19 : Database Model and Entity Relationships of C-DRUG

3.2.2 Web Service Implementation

"A Web service is a method of communication between two electronic devices over the World Wide Web. A Web service is a software function provided at a network address over the web or the cloud, it is a service that is always on as in the concept of utility computing." [28]

The W3C also states, "We can identify two major classes of Web services, REST-compliant Web services, in which the primary purpose of the service is to manipulate XML representations of Web resources using a uniform set of "stateless" operations; and arbitrary Web services, in which the service may expose an arbitrary set of operations."

C-DRUG has its own webservice implementations to realize business logics in application at one point. These services are used in all interfaces such as web site, mobile site, or intelligent drug dispenser. One of the webservices method of C-DRUG, called as getPatientInfo, is presented in below.

Request with data is posting from interface (web, mobile, etc) to the webservice. Whenever webservice gets the request, it initiate to run business processes. Within a miliseconds, it constitute a result called as a response for that request. Then, finally, it pushes response to the interface called as a client.

C-DRUG has almost 45 web service methods to process requests at a single point to avoid reworks for same jobs.

```xml
▼<wsdl:types>
 ▼<s:schema elementFormDefault="qualified" targetNamespace="http://rtms.org/">
  ▼<s:element name="getPatientInfo">
   ▼<s:complexType>
    ▼<s:sequence>
       <s:element minOccurs="0" maxOccurs="1" name="ssn" type="s:string"/>
     </s:sequence>
    </s:complexType>
   </s:element>
  ▼<s:element name="getPatientInfoResponse">
   ▼<s:complexType>
    ▼<s:sequence>
       <s:element minOccurs="0" maxOccurs="1" name="getPatientInfoResult" type="tns:PatientInfo"/>
     </s:sequence>
    </s:complexType>
   </s:element>
  ▼<s:complexType name="PatientInfo">
   ▼<s:sequence>
      <s:element minOccurs="0" maxOccurs="1" name="Name" type="s:string"/>
      <s:element minOccurs="0" maxOccurs="1" name="Surname" type="s:string"/>
      <s:element minOccurs="0" maxOccurs="1" name="Email" type="s:string"/>
      <s:element minOccurs="0" maxOccurs="1" name="Status" type="s:string"/>
      <s:element minOccurs="1" maxOccurs="1" name="PhoneNumber" type="s:int"/>
    </s:sequence>
   </s:complexType>
  </s:schema>
 </wsdl:types>
▼<wsdl:message name="getPatientInfoSoapIn">
  <wsdl:part name="parameters" element="tns:getPatientInfo"/>
 </wsdl:message>
▼<wsdl:message name="getPatientInfoSoapOut">
  <wsdl:part name="parameters" element="tns:getPatientInfoResponse"/>
 </wsdl:message>
▼<wsdl:portType name="Service1Soap">
 ▼<wsdl:operation name="getPatientInfo">
   <wsdl:input message="tns:getPatientInfoSoapIn"/>
   <wsdl:output message="tns:getPatientInfoSoapOut"/>
  </wsdl:operation>
 </wsdl:portType>
```


Figure 20 : *getPatientInfo* webservice of C-DRUG

3.2.3 Web Site Implementation

C-DRUG has a web site which is main component. The web site built on detailed design with advanced image editors and design tools such as Photoshop. In addition to that improved framework such as jQuery libraries, html5 libraries and CSS are used to develop web site. These make web site useful and attractive for the visitors.

C-DRUG supports Multilanguage. All notifications, messages and warnings can be defined by Supervisor for any language without development or coding processes.

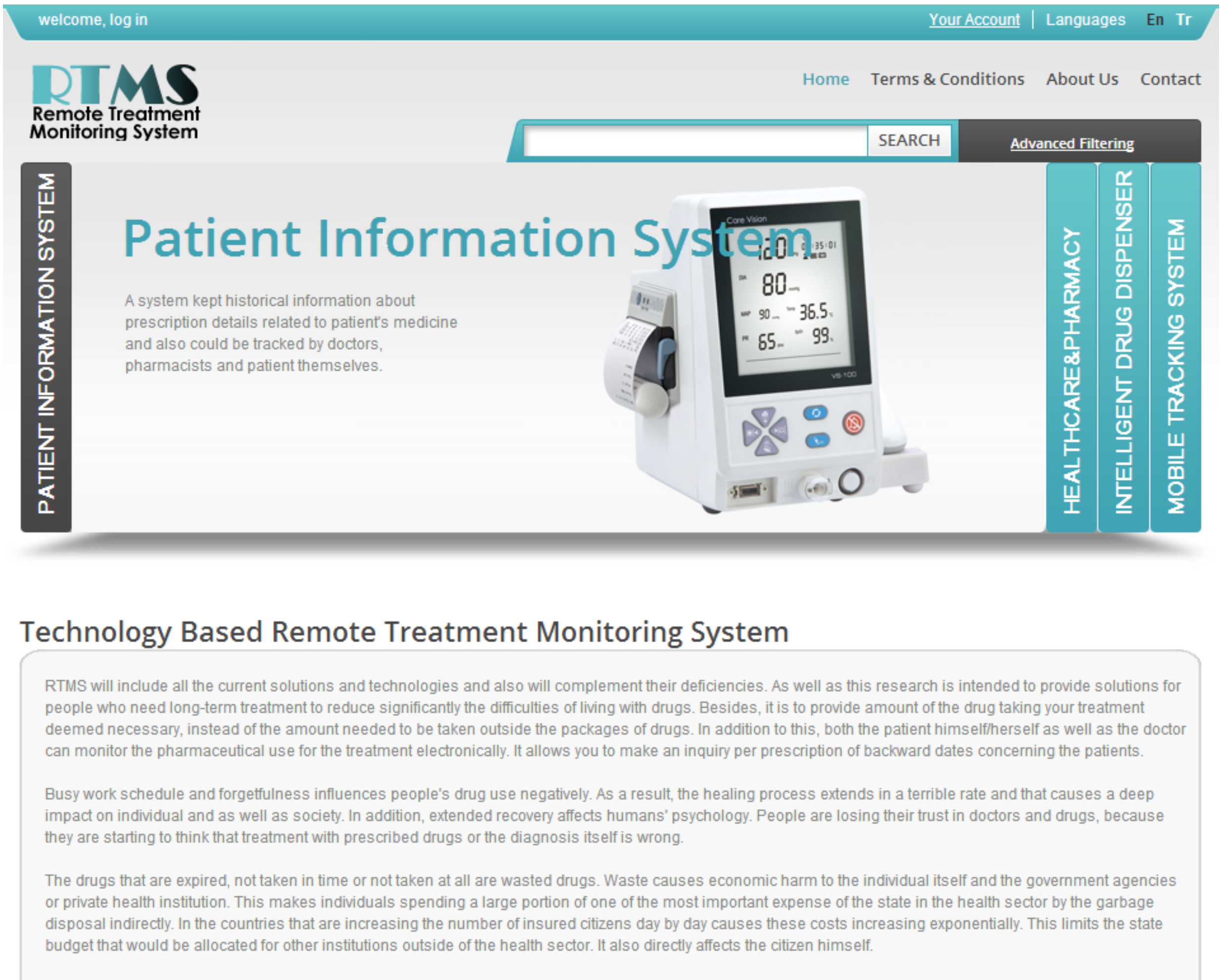

Figure 21 : Web Site of C-DRUG with the view of anonymous user

Registered users, patients or guests can access to the web site. According to roles of visitors, web site has a special behaviour. Every role has their own menus and screens to do their jobs smoothly.

A user with the Supervisor role logged in system for example shown in Figure 22. Supervisor has all privileges in system so that they do all necessary jobs in system. All items in menu can be seen and accessible for that role.

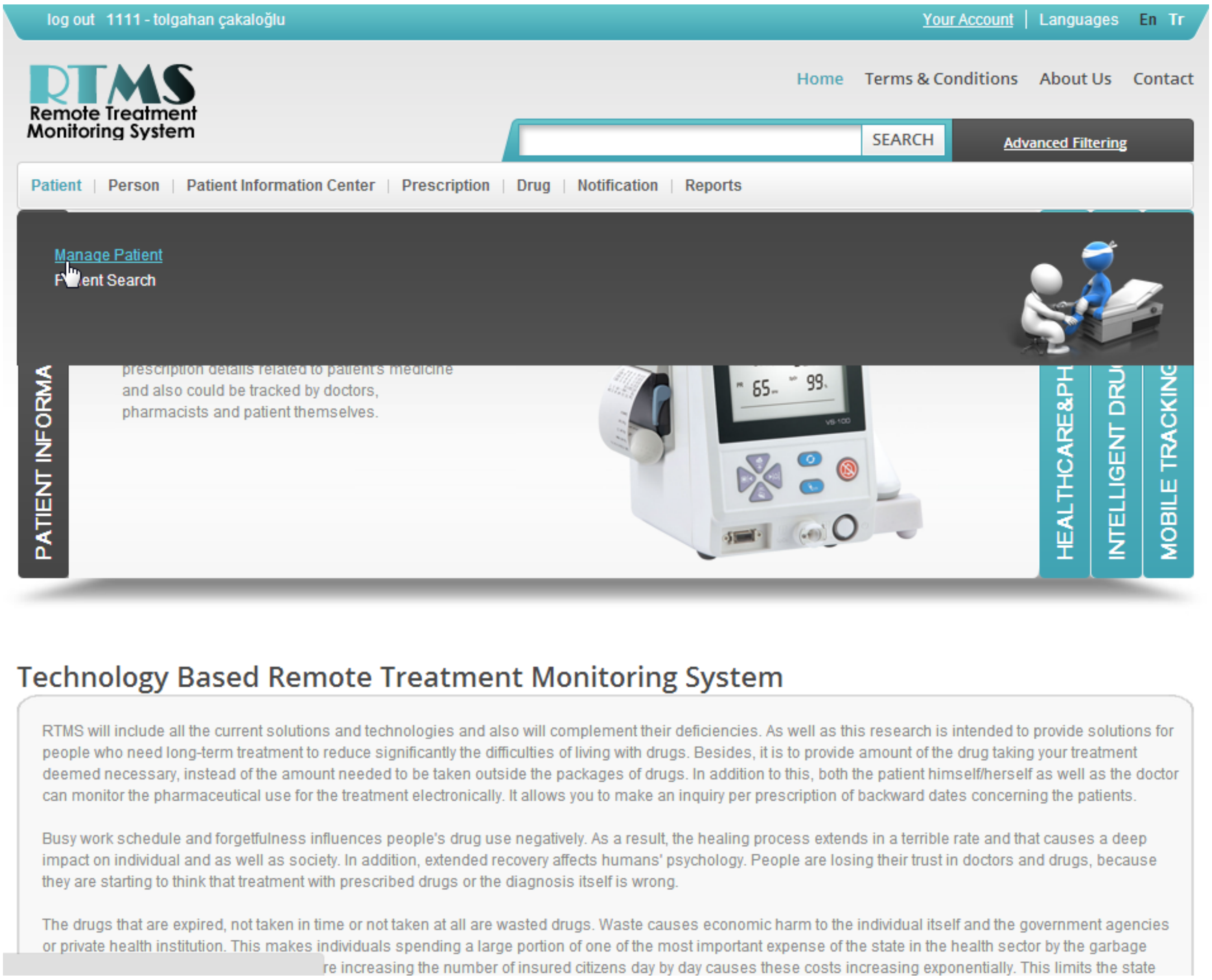

Figure 22 : Web Site of C-DRUG with the view of Supervisor

A user with the Doctor role logged in system for example shown in Figure 23. Doctor has not all privileges in system so that they do only jobs which are related to their role. "Add New Prescription" screen can be seen in Figure 23.

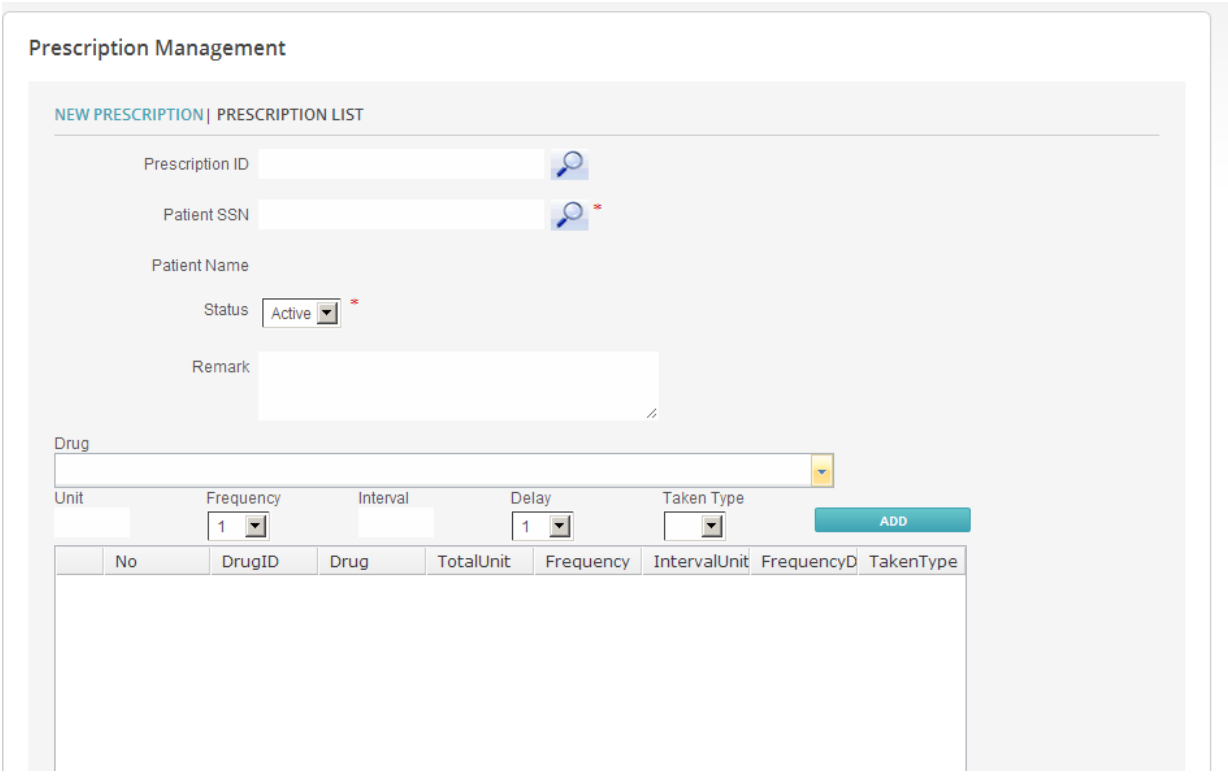

Figure 23 : Web Site of C-DRUG, “Add New Prescription” screen, with the view of Doctor

Favicon is used in C-DRUG web site to improve quality of site at visitor side. Furthermore, it differentiates browser tab from others site. Favicon file is used with the <head> tag at header part in html file.

<LINK rel="shortcut icon" href="localhost:55759/images/favicon.ico" />

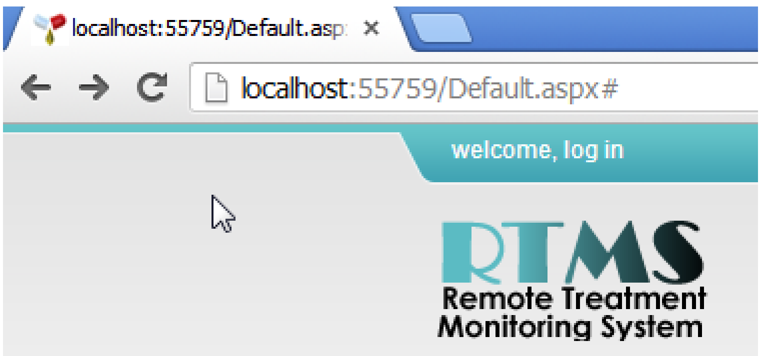

Figure 24 : Usage of favicon in C-DRUG Web site

C-DRUG can generate different type of reports and statistics. According to its' data, it provides many report option to the users. In Figure 25, report called " Number of drug and drug usage in C-DRUG Annually" is presented.

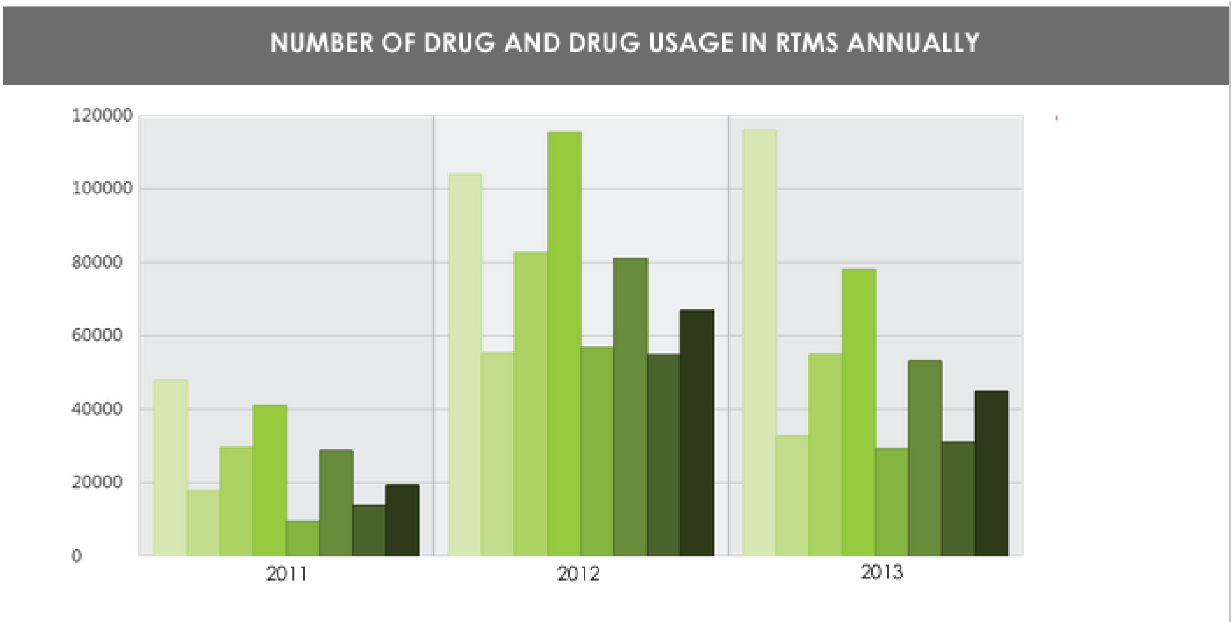

Figure 25 : Number of drug and drug usage in C-DRUG Annually Report in Web Site

3.2.4 Mobile Implementation

As stating before, C-DRUG web is based on html5 and jQuery technology. So, C-DRUG has a mobile implementation for patients to gather instantaneous data from C-DRUG. Patient can query all reports related to himself/herself via mobile.

The Healthcare Dashboard sample demonstrates the capabilities of C-DRUG controls working together into a single complex view designed for mobile tablet devices. The main part of the sample is several charts displaying different kinds of information about patients admitted to the emergency ward of a hospital. The sample shows how the same information can be displayed in a grid and how to switch between views.

Combo boxes are used to select different medical parameters to be displayed and thus switch dynamically the data behind the charts. Additional buttons allow to dynamically change chart visualization with the same data.

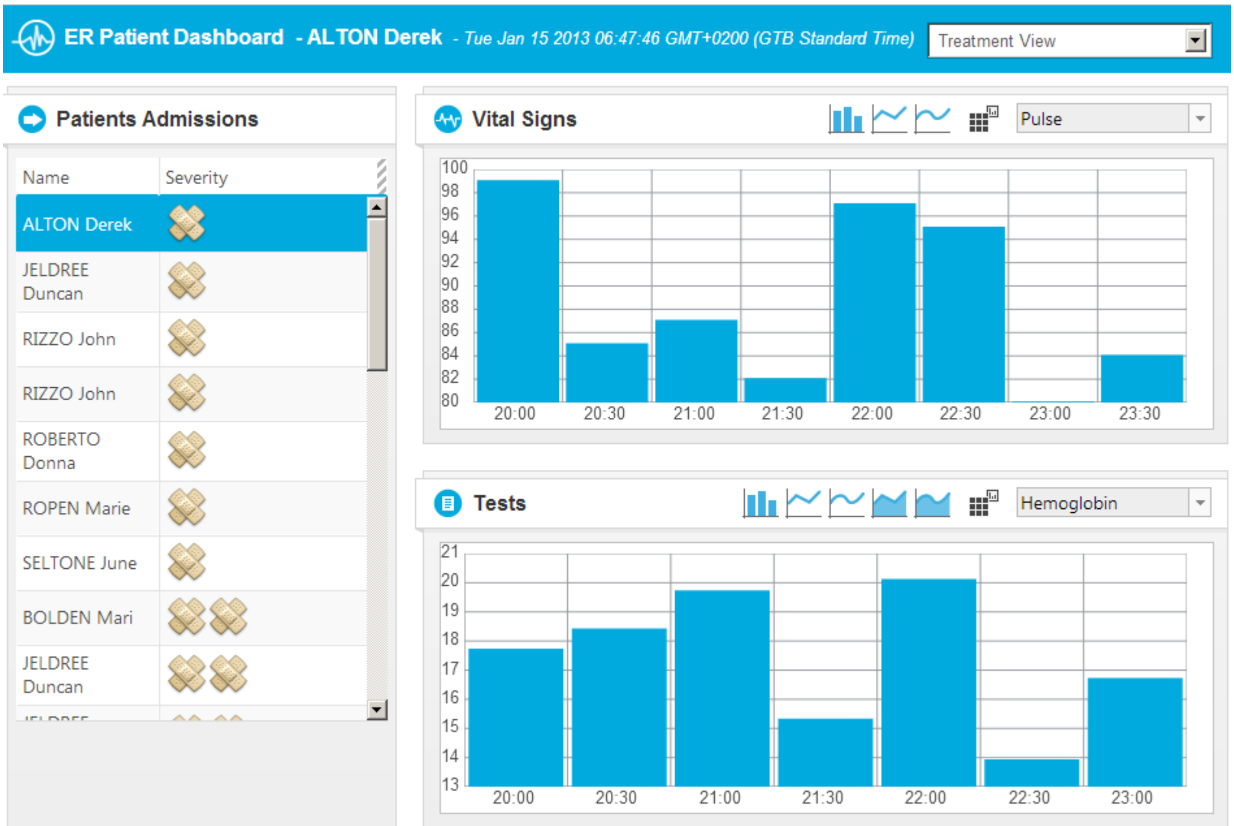

Figure 26: C-DRUG Mobile Mock Up

3.2.5 Intelligent Drug Dispenser Simulation Implementation

HTML5 Canvas is used to demonstrate Intelligent Drug Dispenser. "The <canvas> element is used to draw graphics, on the fly, on a web page. The HTML5 <canvas> element is used to draw graphics, on the fly, via scripting (usually JavaScript). The <canvas> element is only a container for graphics. You must use a script to actually draw the graphics. Canvas has several methods for drawing paths, boxes, circles, characters, and adding images." [29]. Internet Explorer 9, Firefox, Opera, Chrome, and Safari support the <canvas> element.

In project, KineticJS is used to create simulation for IDC. Kinetic stages are made up of user defined layers. Each layer has two canvas renderers, a scene renderer and a hit graph renderer. The scene renderer is what you can see, and the hit graph renderer is a special hidden canvas that's used for high performance event detection. Each layer can contain shapes, groups of shapes, or groups of other groups. The stage, layers, groups, and shapes are virtual nodes, similar to DOM nodes in an HTML page. Here's an example Node hierarchy:

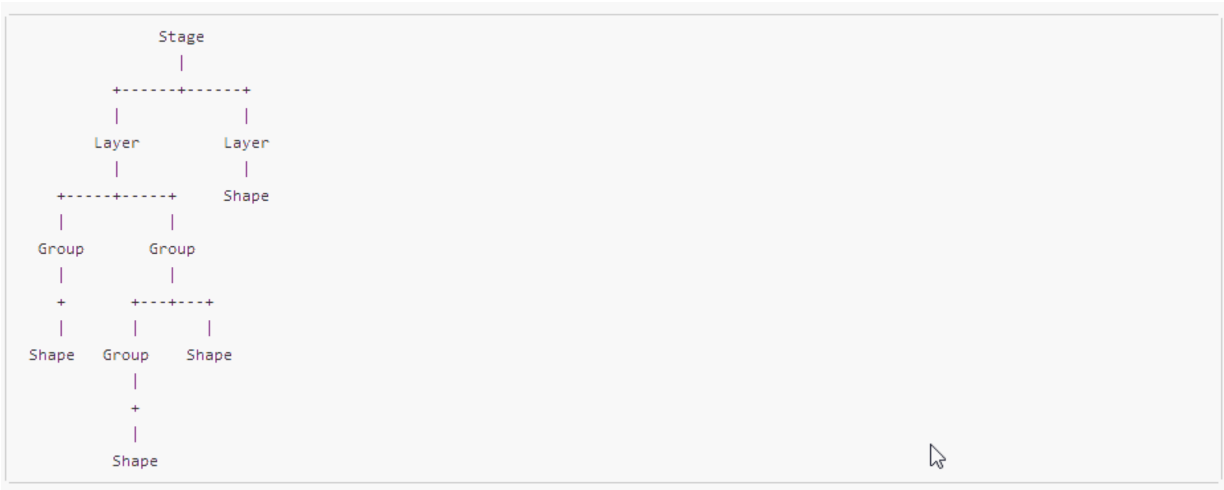

Figure 27: Node Hierarchy of KineticJS

All nodes can be styled and transformed. Although KineticJS has prebuilt shapes available, such as rectangles, circles, images, sprites, text, lines, polygons, regular polygons, paths, stars, etc., you can also create custom shapes by instantiating the Shape class and creating a draw function.

Once you have a stage set up with layers and shapes, you can bind event listeners, transform nodes, run animations, apply filters, and much more.

IDC Simulation begins with animation that tubes with medicines drops into the IDC in sequence based on prescription information.

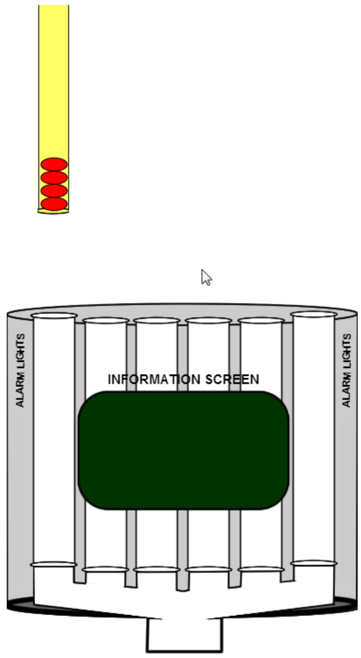

Figure 28: Red Medicines in Tube is placing 1st into IDC

Whenever all tubes are dropped into IDC, alarm lights are switched on. Later, it plays sound for patient.

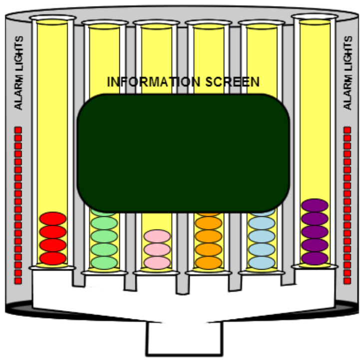

Figure 29: Orange Medicines in Tube is placing in 4th into IDC

It is ready to simulate dispensing of drugs with its' multifunction. Information screen can show all the transactions that system makes.

4. CONCLUSION

The one of the major problems of the healthcare center are the non-adherence problems. To solve these problems, new methods and programs on specific areas such as simplifying dosage regiments and delivering, educating the patient, communicating with the patient, and modifying the patients' behavior are being developed in the last years. Some of these require direct doctor attention and some of them include drug dispenser tools.

C-DRUG is a complete solution by including all recent solutions to address the non-adherence problems. C-DRUG would track every phase of the prescribed medicine picked up from the pharmacist until it is taken the medicine by the patient by using its application based HRS, MTS and device based IDC.

To solve the non-adherence problems, a solution has to make sure that patients are taking their medicine without wasting or forgetting them and this information could be tracked by the doctors at any moment.

C-DRUG has a two-layer solution to make sure the patients are taking their medicines which are MTS and IDC. MTS is a mobile application which is always with the patient and inform the patients when their medicine time came. MTS also shows old medicine history of the patient. Using MTS, patients can look up and track their medicine schedule at any time and if patients would like take a medicine on a different time from scheduled time for any reasons, they can update this information on MTS to hold the correct information on the system.

IDC is a hardware used for maintaining patients' medicine usage to inform them by using scheduled medicine times. IDC has a medicine tubes to hold the medicine until the scheduled time came and then automatically drop them to the medicine cap.

After dropping medicine to the cap, IDC inform patient to take the medicine by using various method such as alert, email, SMS. The different from the other dispensers, if the scheduled medicine not taken, IDC automatically send the medicine its tube again. This way, patients does not waste medicine.

Also, by using HRS application, the doctors and patients themselves can track every step and current situation actively. In HRS, there are reports regarding patients' medicine usage, alert status, and medicine history that could be accessed by the doctors and patients themselves.

In conclusion, C-DRUG by combining current solution and completing their missing points presents a complete solution for a critical problem, patients' non-adherence problem and prevent the medicine waste that causes economic harm to the individual itself and the government agencies or private health institution.

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APPENDICES

A.1 C-DRUG Survey for Doctors

Internet and Social Networks Link
http://C-DRUG.doctor.questionpro.com/

Paper Format for Manual Filling

Yasiniz : Cinsiyetiniz : Sehir :

1. Gunde kac adet hasta tedavi ediyorsunuz?
   a) 1 - 9 b) 10 - 49 c) 50 – 99 d) 100 veya daha fazla

2. Gunde kac adet recete yaziyorsunuz?
   a) 1 - 9 b) 10 - 49 c) 50 – 99 d) 100 veya daha fazla

3. Tedavisine basladiginiz hastalarin % kaci tekrar sizinle iletisime geciyor?
   a) %5 - %19 b) %20 - %39 c) %40 - %79 d) %80 - %100

4. Yazdiginiz recetelerde ilaclarin tamami kullaniliyor mu?
   a) Bilgim Yok b) Hayir c) Bir Kismi Kullaniliyor d) Evet

5. Yazdiginiz recetenin hasta tarafindan uygulandigini ne kadar yakindan takip edebiliyorsunuz?
   a) Takip edemiyorum
   b) Kismen takip edebiliyorum
   c) Mumkun oldugunca takip ediyorum
   d) Tamamen takip edebiliyorum

6. Hasta tarafindan recetenin uygulandigini takip edebiliyorsaniz, takip etmede izlediginiz yol nedir? Aciklama :
   ………………………………………………………………………………………

7. Hasta tarafindan recetenin uygulandigini takip edemiyorsaniz, takip edebilmeyi saglamak icin nasil bir kurgu olmasini istersiniz? Aciklama :
   ………………………………………………………………………………………

8. Gunde ortalama kac kutu ilac yaziyorsunuz?
   a) 5 – 10 b) 11 – 29 c) 30 – 49 d) 50 veya daha fazla

9. Yazdiginiz recetelerdeki ilaclarin kullanim zamanlamasi nasildir?
   a) Sabah b) Sabah–Oglen c) Sabah –Aksam d) Sabah-Oglen–Aksam

10. Yazilan recetelerdeki ilaclarin kullanim sureleri nedir?
    a) 1 - 3 Hafta b) 1 - 3 Ay c) 4 - 6 Ay d) 6 - 12 Ay

11. Hastalarin verilen receteye bagli ilaclari, kullanma öolcusu ne kadardir?
   a) Ilaclar tam vaktinde aliniyor
   b) Ilac kullanimi yetersiz
   c) Hicçdikkat edilmiyor
   d) Ilaclar kullaniliyor fakat tam saatinde alinmiyor

12. Tedavi sureci tamamlanmadan, recetede yazdginiz ilaclari kullanmayi birakan hastalarinizin, tedavisini yaptginiz hastalariniz icerisindeki orani nedir?
   a) %5 - %19
   b) %20 - %39
   c) %40 - %79
   d) %80 - %100

A.2 C-DRUG Survey for Public

Internet and Social Networks Link
http://rtms.public.questionpro.com/

Paper Format for Manual Filling

Yasiniz : Cinsiyetiniz : Sehir :

1. Elinizde kullanmadiginiz kaç kutu ilac var?
   a) Hiç yok b) 5 – 20 c) 20 – 40 d) 40 veya daha fazla

2. Doktora gitmeden, recetesiz ilac kullanirmisiniz?
   a) Hic kullanmam
   b) Nadiren kullanirim
   c) Onemine gore kullanirim
   d) Surekli kullanirim

3. Recetesiz ilaci, hangi bilgiye gore kullanirsiniz?
   a) Ayni ilaci daha once receteli olarak kullanmistim
   b) Ayni ilaci kullanan bir arkadasimin tavsiyesi ile kullanirim
   c) Ayni ilaci kullanan aile uyesinin tavsiyesi ile kullanirim
   d) Yazili ve gorsel medyadan gordugum yada okudugum bilgi ile kullanirim.

4. Neden doktora gitmeden, recetesiz bir ilac kullanirsiniz? Aciklama :
   …………………………………………………………………………………………

5. Verilen receteye bagli ilaclari kullanma öolcunuz ne kadardir?
   a) Ilaclari tam vaktinde aliyorum
   b) Ilac kullanimim yetersiz
   c) Hic dikkat etmiyorum
   d) Ilaclari kullaniyorum fakat tam saatinde almiyorum

6. Recetede yazilan ilaclari, hastalaginiz boyunca kullanip, tamamen tuketir misiniz?
   a) Tamamen tuketirim
   b) Kismen tuketirim
   c) Kendimi iyi hissedince, ilac kullanmam
   d) Cogunlukla tuketmem

7. Recetede yazilan ilaclarin kullanmadiginiz kismini ne yaparsiniz?
   a) Atarim
   b) Ecza dolabimda saklarim
   c) Cevreme veririm
   d) Saglik kurumuna teslim ederim

8. Kendinize, ilaclarin kullanim periyodunu nasil hatirlatiyorsunuz?
    a) Hafizama guvenirim
    b) Yardimcim yada yakinim var o bana gerekeni soyler
    c) Telefonuma alarm kurarim
    d) Hatirlatici, akilli sistemler kullanarak ilacimi alirim

9. Ilaclarin kullanimi bittikten sonra, tekrar doktorunuzla gorusurmusunuz?
    a) Hayir gorusmem
    b) Nadiren gorusurum
    c) Tedavimin onemine gore gorusurum
    d) Evet kesinlikle gorusurum

10. Doktorunuzun, yazilan receteye bagli kalip kalmadginizi takip ettigini dusunuyor musunuz?
    a) Kendisine bilgi vermiyorum
    b) Kendisi bana bununla ilgili soru sormuyor
    c) Kendisine bilgi veriyorum, benimle ilgili dikkatli bir şekilde notunu aliyor
    d) Kendisine bilgi veriyorum ancak benimle ilgili not almiyor

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