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Design and Implementation of Mobile Patient Monitoring System

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ABSTRACT

The development in the mobile technology and in the parallel of this, the development in the NFC technologies generalize usage of these technologies and allow that awareness and usability in teletype systems, bill payment systems, patient monitoring systems. Smartphones can get data from their close environment and also they have the ability that get and process data from sensors in the distance of between 4cm-100m through Bluetooth NFC technologies. Mobile Patient Monitoring Systems (MPMS) grow up every day because of the having these features that reducing cost, attainability, accessibility to patient clinical data. In this research MPMS allows that taking measurement of diabetes, body temperature, heart rhythm of elderly people and children who require follow-up in their school, workplace and cottage hospitals. Then we have transferred to the main server and the relevant departments by categorizing the instant measurement values in two groups as normal and critical measurements.

Keywords: Family Practice, Patient tracking, Mobile Patient Monitoring Systems, NFC, Real Time Monitoring, Telemedicine

INTRODUCTION

Health services are one of the most important needs in human life. To give more qualified services to their patients' health services use the innovative mobile patient monitoring system (MPMS) solutions to improve health care systems and to give better service. Nowadays technology plays a crucial role to improve health services [1-3].

At the present time the usage of mobile applications in any area and desire of people who want to be on-line every time affect and change the development of telemedicine technologies in health sector as like the all sectors. In telemedicine technologies and other areas million applications are developing in nowadays and are served to users. These applications have many properties besides bring solutions to problems that the users faced in daily life. Along the increase in mobile applications make easier patient tracing and increase saving in institutions. With the mobile patient tracing system in this context it's supplied that no need to go hospital for basic measurements and continuous monitoring and also storing the measurements in a central storing system. Also it's aimed that accelerate the treating to urgent patience by separating the normal and urgent measurements. In epitome firstly the data taken from the heat, temperature, diabetes and heart rhythm sensors sent to the Arduino micro controller system then sent to the mobile device which has Android operating system and supported NFC or Bluetooth and lastly sent to the central storing system by this mobile device.

BACKGROUND AND MOTIVATION

NFC usage on patient monitoring systems provides effective communication for collecting patients instantaneously and real time data transmit patients' parameters to the health services and get feedback. Near Field Communication technology advances such applications utility. The patient monitoring system design and implementation will be realized. The main aim of the system is to accelerate effectiveness and utility of family health center services through early diagnosis, cure and monitoring which will increase patients' lives quality. These applications are not design for only elder patients, our study is design for all patients which discriminates this study from the other studies.

There is a challenge in integration of heterogeneous information systems with increasing number of involved systems having complexity in an unmanageable way [4].

In the health sector and the others wireless technologies and NFC which is one of wireless technologies are being used often times. NFC technologies have place by having these properties which having security advantage and easy usage. Especially the increase in the usage of NFC technologies in the other sector increases the usage in the telemedicine sector.

The domain of health can potentially benefit from NFC technology in the following issues [5]:

- Health care Management Systems (hospital billing systems, etc.)
- Diagnosis and Medication by Professionals (Monitoring of correct medication administration and to trace the extremely important data, etc.).
- Specific Applications (for the disabled, elderly, and people with chronic diseases, etc.)
- Health care Monitoring Systems (patient monitoring and care, etc.)

NFC based MPMS intended success criterias are listed below:

- A realization of design and application of NFC enabled mobile devices based local patient monitoring system been done.
- Family Practice service be served more quickly and more effectively by the aid of NFC based patient monitoring system.
- Patients in medically compromised like the elderly patients' lives quality will be increase.
- The big challenges of using information technologies in health care systems are to manage the big number of patients and their diverse data. NFC enabled mobile phones applications use in the health services comes out as a promising solution.

DESIGN AND IMPLEMENTATION OF MOBILE PATIENT MONITORING SYSTEM

In the developed mobile patient monitoring ecosystem the taken data are classified in three groups. D type data: it contains normal interval measurement data. Normal interval data: routine data which does not contain danger. These data are transferred to server on depending the wish of the user. The patient or doctor can check the data if they are transferred to the server. A type data: It shows the critical data. And it could require emergency response. For that reason a type data immediately are shared with doctor and health staff. R type data: it contains diagnostic data which decided by doctor.

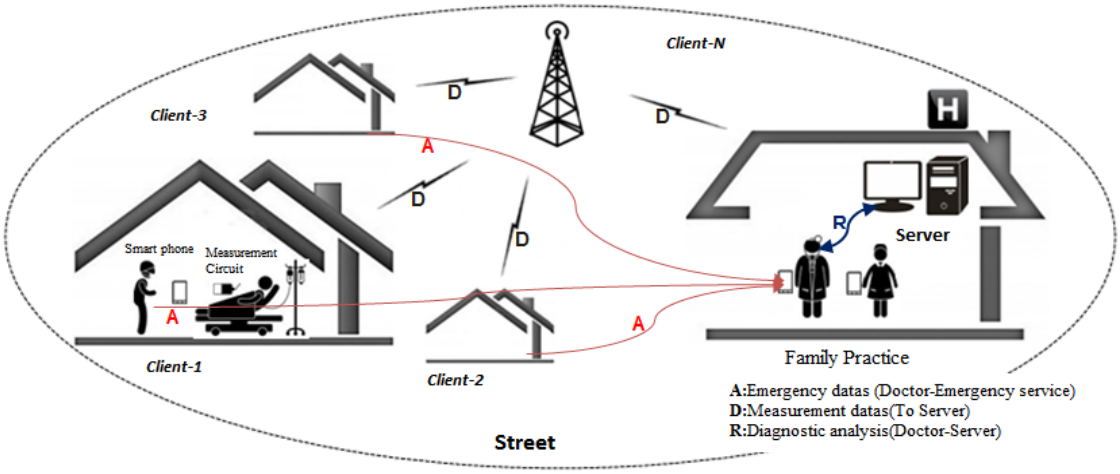

Figure 1. The developed mobile patient monitoring system components

In Figure 1, life cycle of patient monitoring system is given: the data comes from the measurement circuits can be send to the health center by using "Patient Android Program". The patient can send his/her own parameters or patient's relatives can send the parameters, transmission is carried out in real time and the privacy of patient is preserved. The family doctor can be track the patients instant parameters and send the information to the health center's database by using "Doctor Android Program". If there is a precarious

condition, he can send immediate medical response team to the patient's location. The system will be transferred automatically to immediate medical service, if the doctor is not in touch.

The developed system has 2 units as hardware unit and software unit. Hardware unit occur from centrically Arduino[6] micro controller, NFC and sensor circuits. Software unit occur from mobile application which is developed for Android operation systems. In that system patients can monitor the data which is taken from related sensors depending their diseases and these data transferred to central server by NFC device by mean time the doctor also can monitor these data.

The system is activated after the transfer of the needed clinical data to the central server by the user. These are can be seen on algorithm/flowchart at Figure 2;

a. The patient activate the mobile application

b. The patient place the sensors which desire to see the results of measurement and transfer to the central server

c. After 30 seconds the patient bring close the NFC mobile device to NFC antenna.

d. The patient monitors the clinical data on the mobile application screen. Then, if desired, these data are transferred to the central server.

The system is designed to automatically write to the server and send out mail when the measurement values are critical / emergency.

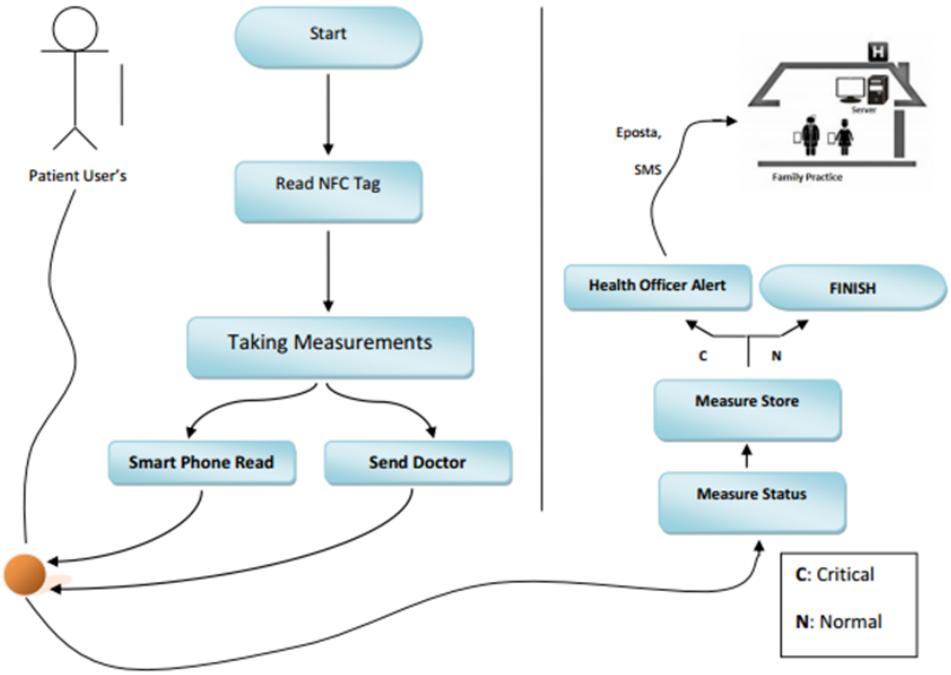

Figure 2. The developed mobile patient monitoring system algorithm

Software Components of the System

In that system it's used that totally open source code for transferring and saving the data taken from the measurement circuit to the central server and for letting to analyze by authorized persons. We can put in order the components like micro controller code which run on Arduino SDK, mobile application which run on Android operation system and MySQL database management to keep data on a remote server.

In that system mobile application has a key role. Mobile application is look like an interface while it is communicating with the hardware unit and also it is used for transferring the taken clinical data to remote

server. The patient can reach its old clinical information via mobile application. While developing the mobile application Eclipse IDE and Android SDK programs are used.

Mobile application needs user verification at first. The user verification is made from remote server via web service. If the user is not registered to the system, user can register via application to the system.

The users can access measured retrospective clinical data, measurement data, measurement date, doctor info, clinic info and related diagnosis. The system is designed as if the measurements data are urgent system send these data directly to the server and mail them to the doctor.

Here at Figure 3, it is seen that main menu for the mobile application's users. Via that menu new clinical measurements can be done from Data Measure screen. Via Service Testing menu the existing services can be tested, via Old Clinic Data menu the old clinical data can be examined. Places button and Events button are added to here for adding the patient's location and medicine using calendar.

(a) (b)

Figure 3. (a) Main menu window of developed MPMS, (b) Data Measure screen

Hardware Components of the System

The measurement circuit components are shown in Figure 4. The hardware components of measurement circuits are; NFC enabled device for taking the ID of patient, e-Health sensor platform for taking diabetes, oxygen, body temperature measurements, Arduino micro controller platform for processing these data and lastly wireless network system to transfer these processed data to the server.

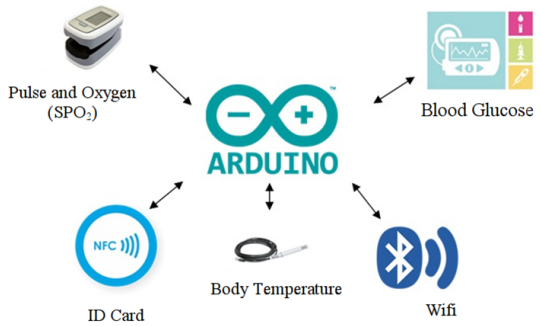

Figure 4. MPMS's Hardware Ecosystem

NFC: NFC [7] is rooted in radio-frequency identification technology (known as RFID); this feature allows compatible hardware to both supply power to and communicate with an otherwise unpowered and passive electronic tag using radio waves. This is used for identification, authentication and tracking. It is a set of communication protocols that enable two electronic devices, one of which is usually a portable device such as a smart phone, to establish communication by bringing them within about 4 cm (2 in) of each other.

NFC is a set of short-range wireless technologies, typically requiring a separation of 10 cm or less. NFC operates at 13.56 MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 Kbit/s to 424 Kbit/s. NFC always involves an initiator and a target; the initiator actively generates an RF field that can power a passive target. This enables NFC targets to take very simple form factors such as passive tags, stickers, key fobs, or cards. NFC peer-to-peer communication is possible, provided both devices are powered.

Arduino: Arduino is an open-source electronics platform based on easy-to-use hardware and software [6]. Arduino was originally developed in Ivrea, Italy. Arduin of Ivrea was the king of Italy about a thousand years ago and is celebrated in local history. The name Arduino is a masculine Italian name meaning "strong friend"[8]. Arduino Uno is a micro controller which based at Atmega328. Because of being flexible while using it's preferred for scientific research and for hobbies.

E-Health sensor shield: The e-Health Sensor Platform [9] has been designed by Cooking Hacks in order to help researchers, developers and artists to measure biometric sensor data for experimentation, fun and test purposes. It includes the following sensors: Pulse and oxygen in blood sensor (SPO2), body temperature sensor, electrocardiogram sensor (ECG), glucometer sensor, galvanic skin response sensor (GSR - sweating).

RESULTS AND PERFORMANCE EVALUATION

After design to evaluate and test the MPMS some example data taken from an example patient in different time periods in the day and showed in graph. At test phase the example patient is 60 years old diabetic and it needs monitoring all the time. The diabetes, heart rhythm, body temperature measurements taken from patient and recorded to system while patient hungry and full in the different time periods in the day for examination.

Figure 5 shows the body temperature measurements of patient which is taken 3 hours periods in a day. For a healthy person body temperature is seen in range 36.6-38 °C, below 34 °C and over 40 °C temperatures means abnormal situations.

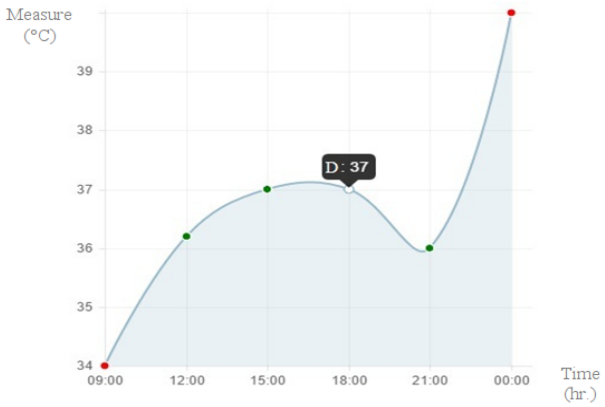

Figure 5. The body temperature measurements of the patient

At Figure 6 shows the oxygen saturation of patient which taken 3 hours periods in the day. In healthy people, normal SpO2 or blood oxygen saturation levels should range from 94 to 99 percent. For a person with a mild respiratory disease, the value should be at least 90 percent [10]. For a healthy person the oxygen saturation value should be at least Spo2 91% below this value means abnormal situation. For health rhythm it's normal in this range 40-100 bpm below or over that value shows there is an abnormal situation.

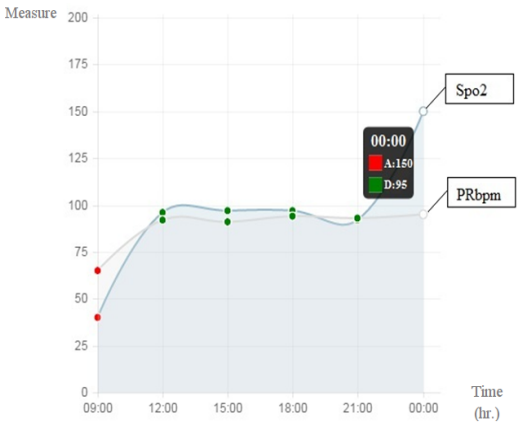

Figure 6. The oxygen saturation and rhythm of the patient

In Figure 7 its shown that the diabetic values in blood of the patient while the patient is hungry and full which is taken in 3 hours periods in a day. The diabetes measurements shows alteration depending the patient is hungry or full. For healthy and hungry person diabetic value should be 83 mg/dl (4,6 mmol/L) or less. For a healthy and full person diabetic value should be (after 1-2 hours meal) 120 mg/dl (6,6 mmol/L) or less and it is independent what person eat. The best value for a full person (2 hours after the meal) is 100 mg/dl (5,5 mmol/L).

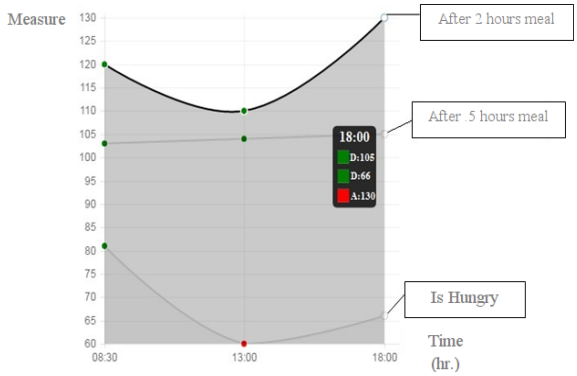

Figure 7. Fasting and postprandial blood glucose of the patient

In the graph the red points show that the results of measurements are abnormal the green points shows that the result of measurements are normal. As the same logic D shows normal, A shows abnormal.

CONCLUSION

After all in this work its aimed that the patient monitoring can be done easily, fast and practically while patient at home or work and the measurements which taken can send to the doctor immediately. To decrease the cost the last user should use its own mobile device while transferring the taken data to the main server. The reason for choice is that mobile devices are common and they have full time access to the Internet. The second way for data transfer is to integrate a GSM shield. GSM shield can work with a GSM card and subscription. After enabled the Internet on this card it can be used as Wi-Fi distribution point.

The system is flexible because it has open source code and it is open to development in both way hardware and software. The patient monitoring system is based web services and it can be easily integrate with 3rd party software like e-pulse and other web services. The system has modular structure and it can be used as online patient monitoring system.

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