Android Smartphone Based Health Monitoring System

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***Abstract*—**The telemedical system focuses on the measurement and evaluation of vital parameters, e.g. ECG, heart rate, heart rate variability, Body Temperature, plethysmography. Based on design of a (Wireless) Body Area Network connected to an Android smartphone the Real-Time system features several capabilities: Data acquisition in the (W)BAN plus the use of the smartphone sensors, patient localization, data storage, analysis and visualization on the smartphone, data transmission and emergency communication with first responders and a clinical server. Smart and energy efficient sensor nodes acquire physiological parameters, perform signal processing and data analysis and transmit measurement values to a coordinator node. In the second design sensors are connected via cable to an embedded system. Data are transferred via Bluetooth to an Android based smartphone.

Keywords- *Body Area Network, Health Monitoring System.*

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I. INTRODUCTION

Health Monitoring System (HMS) has gained attention of many researchers & has created new health and wellness dimensions with a holistic approach to life. Modern medicine, being the most prevalent and widely practiced and are limited only to primary, secondary and tertiary preventions only[1-3]. However, HMS aims to treat symptoms before they could even surface and hence prevent illness. For an illness to develop the first thing which occurs is a change in cell energy levels. If this change is ignored, a change in bio-chemicals occur, if this too is ignored the blood test would show an abnormality and if this is also ignored, structural changes occur and the person falls ill.

Advances in technology were contributed many changes in human daily life as an example mobile phone for this century has become more than a tool for communication. As a born a new generation of mobile phone is known as a Smartphone were support many function such as Internet Browser, Java application, GPS, Bluetooth/infrared and other future functions. These powerful function that supported Smartphone enabled it to use in health monitoring field. portable health systems can comprise various types of small physiological sensors, which enable continuous monitoring of a variety of human vital signs and other physiological parameters such as heart rate, respiration rate, body temperature, blood pressure, perspiration, oxygen saturation, electrocardiogram (ECG), body posture and activity etc. Furthermore, due to embedded transmission modules and processing capabilities portable health monitoring systems can facilitate portable wearable unobtrusive solutions for continuous all-day and any-place health, mental and activity status[4]. monitoring. Basically, the existing system is used for health monitoring only available in hospital and huge in size. Monitoring can be done when the patient is on the bed. From that, monitoring and recording of physiological parameters of patients outside the clinical environment is becoming increasingly important in research as well in applied physiology and medicine in general. The idea is to provide the monitoring system even the patient is not in clinical environment. As a result, patient still can be continuously monitoring even had discharged or can be used as personal health monitoring.

In order to provide the health monitoring system when the patients are out of clinical environment many things needs to be considered. The first thing, need to be considered is mobility. The system need to implement in way unobtrusive the daily life of users, also easy to user to use it (user- friendly) and easy to set up the system. Secondly the cost, low cost system is more prefer to be implemented. Last but not least, reliable data transmissions where the data transmission can be transmit everywhere and anytime.

The main idea for the present work is to develop an Android OS based data collection platform that can collect physiological data from multiple sensors, perform signal processing and analyses, store data in an internal memory and transmit data to clinical server. When the medical parameter exceeds specified limits, automatically message shall be sent to Doctor and Relatives of patient through Mobile SMS.

For the present work, by using the existence device (Smartphone) it will make the cost lowest. As a target market, Smartphone will be conquering the mobile phone market and Android OS uses is were increasing from year to year.

II. SYSTEM DESIGN

System is designed for monitoring vital body parameters like temperature, heart rate and oxygen saturation of blood in terms of rate. The values of these parameters are transmitted to Android Smartphone where it will get processed. Whenever the values of these body parameters falls out of the pre-defined range, Automatically Android Smartphone will use Short Message Service (SMS) facility to alert the Doctor & Relatives. This will grab the quick attention of Doctors & Relatives & immediate medical help can be made available. Thus relatives

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need not be with patient all time, neither patient is required to be in Hospital environments all time to monitor health changes.

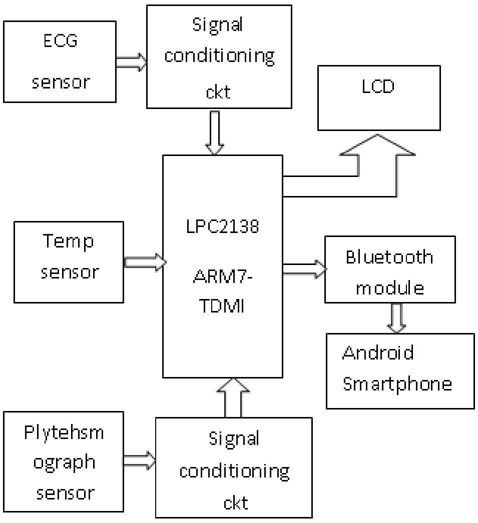

Figure 1. .Block Diagram Of System Designed

Sensors connected to Patient's Body will measure the body parameters, which will be be further amplified and filtered in Signal Conditioning circuits & filters. This processed data is transmitted to Smartphone via Bluetooth module. This data is sent to remote server through wireless technology Wi-Fi. Thus Real time records of measured parameters will be maintained on server which make database for Doctor. Based on which Doctors can advise precautions to be taken & can recommend most correct treatment.

In this work, Biomedical parameters measured are ECG, Plethysmograph & Body temperature, since these are the critical parameters which are measured when a patient is admitted in ICU.

III. DESIGN METHODOLOGY

Figure 2 shows the Circuit prepared for reading & transmitting values of body temperature, Heart rate & Photo plethysmograph. Sensors connected to ARM 7, will actually measure the body parameters, status will be displayed on LCD & via Bluetooth module values will be sent to Android Smartphone.

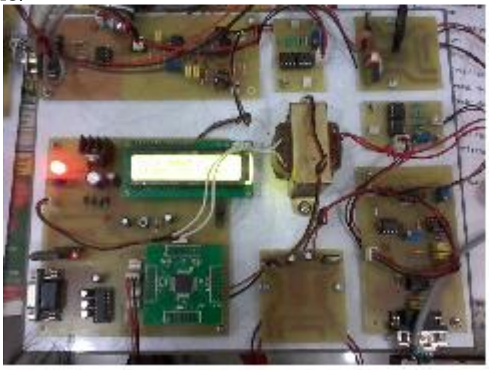

Figure 2. Circuit read & transmit Body Temperature, Heart Rate & PEP

A. WBAN Architecture:

Figure 3 shows the WBAN architecture. In this architecture the primary data processing is done by the sensor nodes, including the physiological signal processing in the ARM 7 processor of the nodes. The secondary data processing is performed in the Smartphone. This includes data

representation, data filtering, graphical interface and data synchronization. Finally the last and most demanding data processing together with the database management is performed in the medical server. The medical server allows local and remote access for Medical personnel via the internet.

Figure 3. WBAN architecture

B. ARM 7 PROCESSOR:

The LPC2138 microcontroller are based on a 32/16 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. Due to their tiny size and low power consumption, LPC2138 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. A blend of serial communications interfaces ranging from a USB 2.0 Full Speed device, multiple UARTS, SPI, SSP to I2Cs and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable for industrial control andmedical systems.

C. Electrocardiography (ECG)

Electrocardiography measures the electrical activity of the heart. The activation of the heart starts at the sino-atrial node that produces the heart frequency, at about 70 cycles per minute. This activation propagates to the right and left atria muscle tissues. At the atrioventricular node, there is a delay to allow the ventricles to fill with blood from atrial contraction. The depolarization then propagates to the ventricles through the Bundle of His and spreads along the Purkinje fibers. Propagation of this activation through these fibers as a function of time . This activates theventricles to contract and pumps blood to the aorta and to the rest of the body. Finally, repolarisation occurs and this cycle is repeated . As the above cycle occurs, the transmembrane potential, which is the voltage difference between the internal and external spaces of the cell membrane, changes at each stage. These voltage differences can be measured using surface electrodes.

The heart rate or pulse rate is the frequency of this heart cycle, and more specifically, the number of heart cycles that occur every minute. Three gold EEG electrodes will be used to get ECG signals using Lead I, Lead II, and Lead III electrode placements. These signals will be sent through a signal conditioning circuit that will filter out unwanted and noisy parts of the signal and output the desired signal. This output signal will be sent to the ADC and into the arm7 processor. Figure 4 shows the Silver electrodes used to measure the ECG of user.

Figure 4. *ECG Silver Bulb Electrodes*

D. *Electroplythesmograph*

Related to measurement of blood flow is the measurement of volume changes in any part of the body that results from pulsations of blood with each heartbeat. Such measurements are useful in diagnosis of arterial obstructions as well as for pulse wave velocity measurements. Instruments measuring volume changes are called plethysmographs and measurement of these volume changes is called plethysmography. The measurement of these blood volumetric changes in the skin perfusion by means of PPG depends on the fact that blood absorbs infrared light many times more strongly than the remaining skin tissues.There are different types of plethysmographs like strain guage, impedance, capacitive and photoelectric plethysmograph (PPG).

Photoplethysmography operates on the principle that volume changes in the limb or digit result in changes in the optical density through and just beneath the skin over a vascular region. A light source in an opaque chamber illuminates a small area of the fingertip or other region to which transducer is applied. Light scattered and transmitted through the capillaries of the region is picked up by the photocell, which is shielded from all other light. As the capillaries fill with blood, the blood density increases, thereby reducing the amount of light reaching the photocell. The result causes resistance changes in the photocell that can be measured on wheatstone bridge and recorded Main applications of PPG include monitoring of oxygen saturation, and in measuring the ankle-brachial pressure index (ABPI) to detect peripheral vascular disease (PVD). Figure. 5 shows the sensor used to measure photo plethysmograph value of the user.

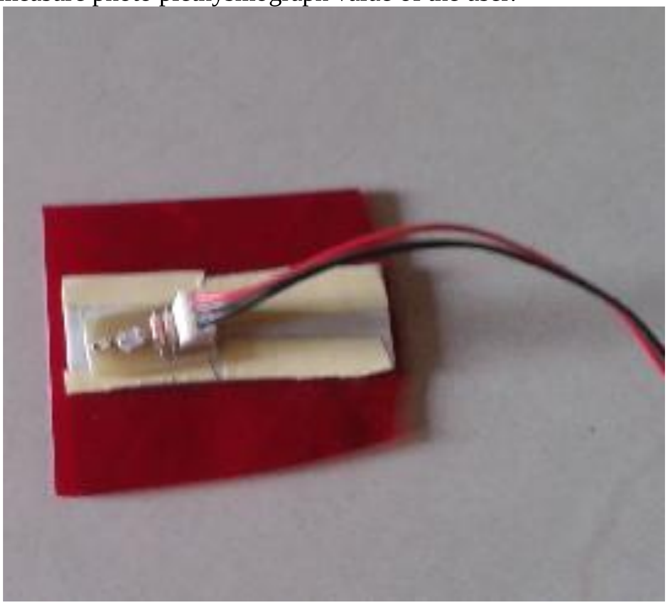

Figure 5. *.Photo Plethysmograph Sensor*

E. *Body Temperature*

Body temperature is lower in the morning than it is in late afternoon and evening. Temperature can vary with other factors, such as exercise, drinking hot or cold fluids, sitting in a cold room, fighting an infection, and by the accuracy and type of thermometer used. The normal core body temperature of a healthy, resting adult human being is stated to be at 98.6 degrees Fahrenheit or 37.0 degrees Celsius. Temperature is important in an athlete. Heat is generated when a person exercises. The body tries to keep the core temperature the same through sweating. It can also cause dehydration as the body sweats to keep its core temperature in a good range. Temperature affects the time to fatigue in an athlete

Different parts of the body have different temperatures. Rectal and vaginal measurements, or measurements taken directly inside the body cavity, are typically slightly higher than oral measurements, and oral measurements are somewhat higher than skin temperature. The commonly accepted average core body temperature (taken internally) is 37.0 °C (98.6 °F). The typical oral (under the tongue) measurement is slightly cooler, at 36.8° ± 0.4°C (98.2° ± 0.7°F), and temperatures taken in other places (such as under the arm or in the ear) produce different typical numbers. Although some people think of these averages as representing the normal or ideal temperature, a wide range of temperatures has been found in healthy people. The body temperature can be measured by

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putting sensor in contact with the body. Sensor used in the system is LM35. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the degree centigrade temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in degrees Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient degree centigrade scaling. The LM35 does not require any external calibration or trimming. The LM35 is rated to operate over a 0° to +150°C temperature range as the body temperature.

F. BLUETOOTH MODULE

HC-05 embedded Bluetooth serial communication module (can be short for module) has two work modes: order-response work mode and automatic connection work mode. And there are three work roles (Master, Slave and Loopback) at the automatic connection work mode. When the module is at the automatic connection work mode, it will follow the default way set lastly to transmit the data automatically. When the module is at the order-response work mode, user can send the AT command to the module to set the control parameters and sent control order. The work mode of module can be switched by controlling the module PIN (PIO11) input level.

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH(Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. Hope it will simplify your overall design/development cycle.

IV. ANDROID APPS

Android software stack is divided in four different layers, which include 5 different groups: The application layer: The Android software platform will come with a set of basic applications like browser, email client, SMS program, maps, calendar, contacts and many more. All these applications are written using the Java programming language. It should be mentioned that applications could be run simultaneously; it is possible to hear music and read an email at the same time. This layer will mostly be used by commonly cell phone users. The application framework: An application framework is a software framework that is used to implement a standard structure of an application for a specific operating system. With the help of managers, content providers and other services programmers it can reassemble functions used by other existing applications. The libraries: The available libraries are all written in C/C++. They will be called through a Java interface. These includes the Surface Manager (for compositing windows), 2D and 3Dgraphics, Media Codecs like MPEG-4 and MP3, the SQL database SQLite and the web browser engine Web-Kit.

An Android based smartphone has been chosen because of its powerful and Java-based development kit, Android SDK, its excellent documentation and library including classes like Bluetooth Health, and the possibility to develop on many platforms, like Linux, Mac Os and Windows . For development different smartphones are being used with Android 2.3.5 and 4.03.

As mentioned in the System Architecture the smartphone should manage not only data acquisition from the W(BAN), but also synchronization and provide a Graphical User Interface (GUI), among other tasks. In order to do so an Android application is necessary, this application should feature several functions, among these are: Data acquisition from the (W)BAN via Bluetooth; data analysis, i.e. comparison with medical norm values; GUI for configuration, data visualization, and communication; data transfer (synchronization) to a medical server via WiFi or cellular network. Android applications are divided into Activity classes. An Activity is both a unit of user interaction, and a unit of execution which provide reusable, interchangeable parts of the flow of UI components across Android Applications. In essence the application is responsible to detect the Bluetooth gateway and establish a full duplex communication, including device discovery, pairing, debugging and communication, and to be able to connect to the medical server through the Internet enabling data synchronization between the server and the W(BAN) in soft real-time.

V. RESULTS & DISCUSSION

Bluetooth hardware connected using android Bluetooth adapter receives the ECG, plethysmograph and body temperature values via Bluetooth, these values gets stored into androids SQLite database which resides in the android phones. After clicking on the start button, Bluetooth class gets connected to the Bluetooth hardware and starts receiving values of ECG, plethysmography and body temperature. Similarly after clicking on upload button, data from the android SQLite database gets uploaded to the server. Graphs for the ECG, plethysmograph and body temperature values can be viewed on server side. After exceeding the predefined values of these parameters, message is received by intended Doctors and Relatives.

Figure. 6 shows the Android proto type application, These are screen shots of Android application developed. First screen shot shows the values of ECG, Plethysmograph, & Body temperature displayed on Android Smart phone which are measured by various sensors as explained above. Second Screen shot shows the mobile number of doctors/ Relatives & IP Address of server to be entered for transmitting the Values measured.

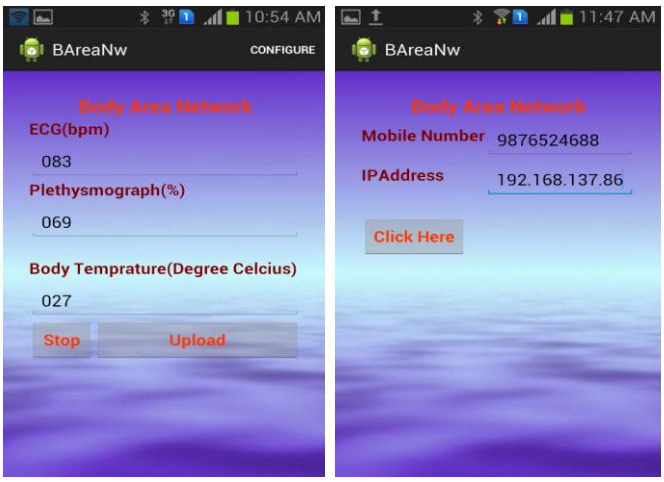

Figure 6. Android Prototype Application

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1721 – 1725

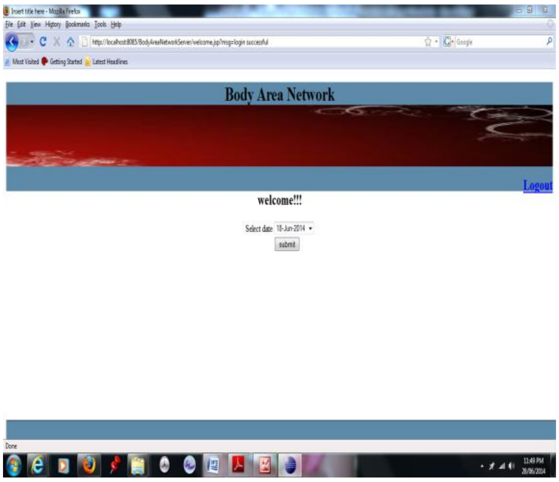

Figure 7. Server for Data Uploading

Figure. 7 shows the Server prepared for uploading the values of Body temperature, ECG & plethysmograph. Server receives the data from Android Smart phove via Wi-Fi technology. This data is stored on the server with date & time. This will help to observe the changes in Patient's body parameters based on which Doctor can give the treatment. Server also shows the graphs of these data's as shown in Figure. 8.

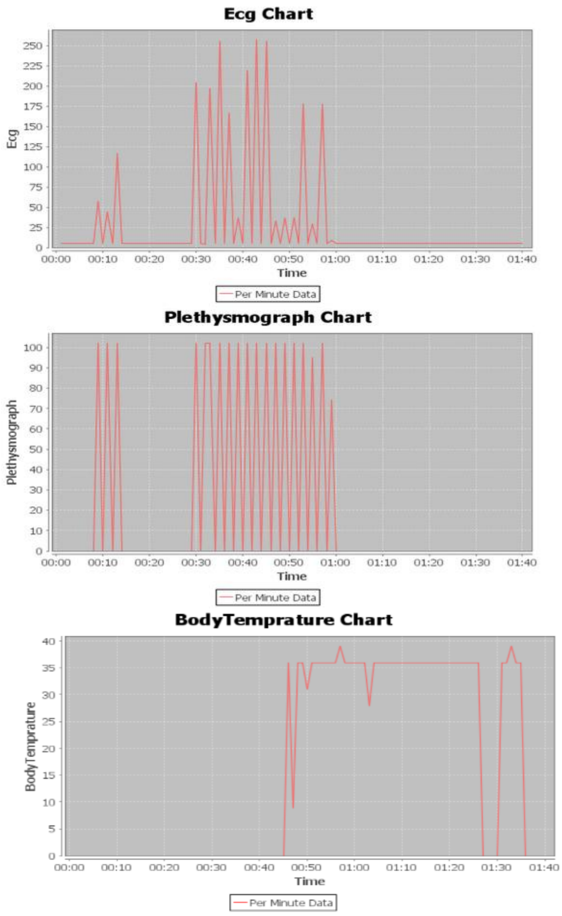

Figure 8. . Body Parameter Graphs on Server

VI. CONCLUSION

WBAN design approach fulfills the basic requirements. Reliability and range are sufficient. As a conclusion, the combination of WBAN with an Android smartphone offers a large functionality. Vital parameters can be stored, analyzed and visualized with GUIs.
Implementation of present work will contribute in research in the area of Environment physiology which will form basis for recommendations and draft guidelines on how and to what extent exposures to extreme environments can be tolerated in a safe way with minimized health risks considering short, medium as well as long term effects.

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