Multi-Purposes u-Healthcare Service System for Smart Mobile Devices

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***Abstract*—In this paper, we had designed and implemented a new multi-purpose u-Healthcare service system that provides ECG, BP, BC, HR and BT measurements and histories on a smart mobile device by using the zigbee network. For smart mobile zigbee network, we developed zigbee sensor module for each u-Healthcare data type and zigbee collector for smart mobile device such as smart phone or smart PAD that has microSD slot interface to make its own zigbee network. We also implemented an android application program to process and analyze the u-Healthcare data sent from zigbee sensor modules that collected on the zigbee collector, to show up the analyzed results on the android smart device, and save the data and results on the server system to retrieve under the ubiquitous environment. This multi purposes u-Healthcare service system can gives more easiness and mobility under the current ubiquitous environment than other mobile healthcare system.**

***Keywords*— Zigbee Network, u-Healthcare, Smart device, Collector, Android**

I. INTRODUCTION

Recently, many interest mobile services have increased due to the rapid development in wireless network and information technologies. In medical device and information area, mobile information system services are rapidly increasing and used on supporting efficient mobile healthcare service in ubiquitous environment. This ubiquitous healthcare so called u-Healthcare opens a new area in medicine so as to provide easy inspection and disease prevention with mobile devices instead of huge, heavy and expensive biomedical devices [1].

A biomedical device has to measure the bio signals from the bio sensors and has to process the signals through computer system in many ways according to result what it want to get. In many cases, sensors connect to device with electric cables. The electric cable is capable to transmit a stable signal but sometimes cables would make electromagnetic interference among the signal paths and cause the complicate installation and maintenance. Moreover, these cables limit the distance between sensors and device, dues to decrease the system mobility. If there is a short-ranged local area network around a body, we can construct a kind of wireless links among the sensors and device that can eliminate the most of cable problems, and it can help implementing efficient u-Healthcare system under the ubiquitous environment [2]. In the biomedical area, many information devices adopt a zigbee technology on forming a wireless network. The zigbee sends small data through fishnet or mesh network in short range [3], [4].

In this work, we had designed and implemented a new multi-purposes u-Healthcare service system based on the zigbee technology. A dedicated zigbee links connect zigbee sensor modules to a zigbee collector of the measurement system. Zigbee Sensor modules are designed for each dedicate bio signal measurement such as ECG(Electrocardiogram), BP(Blood Pressure), BC(Body Composition), HR(Heart Rate), BT(Body Temperature), and a zigbee collector is also designed for receiving multiple signal data from sensors simultaneously. An android smart mobile device takes the collector inside through built-in microSD socket. An android application program had also implemented in this work that services signal data processing, analyzing data, showing up results and sending to a database server. With smart mobile device, this multi-purposes u-Healthcare service system has more easiness and mobility under USN environment. The rest of this paper is composed as follows: Chapter 2 introduced the related zigbee technology and u-Healthcare. In chapter 3, we showed the design concept of hardware modules and software architecture of the multi-purposes u-Healthcare service system, and showed the implementations and results for measuring and data history in chapter 4. Finally we concluded in chapter 6.

II. RELATED RESEARCHES

A. Zigbee

Zigbee is one of the IEEE 802.15.4 based international protocol specification target to the low-cost, low-power, low-speed short-range personnel communication. The zigbee has

low-power consumption and high communication stability, and it becomes the most rapidly progressed technique. It includes network layer, APS (Application Service) layer, security and application layer over the IEEE 802.15.4 physical and MAC layer [3].

The zigbee physical layer has very simple structure and minimizes the power consumption. The zigbee is suitable for remote control, remote management, remote monitoring, and will be applied on home automation, manufacturing automation, industry automation. The most significant feature of zigbee would be its simple function of architecture that can be implemented without any backbone system or infra system so as an easy installation and management. The zigbee specification only emphasizes RF detection, control and monitoring. It can transfer the data with 256Kbps through the carrier among the 27 bands within 75m radius. Star network topology and P2P(Peer-to-peer) network are mandatory supported and can make more complicate network with mesh network so as to cooperate various zigbee devices suitable for sensor network[4].

B. u-Healthcare

The u-Healthcare represents a kind of service combines ubiquitous technology and healthcare service. It means healthcare management and medical service that can provide disease prevention, inspection, treatment and medical after care service anytime, anywhere outside the hospitals. As the medical service progresses, the concept of u-Healthcare also upgrades and emphasizes more on the high quality medical service and high efficient service providing for sustaining healthy life for a long time by early disease detection and treatment through delicate disease prevention than treatment and care service after a disease occurred[2].

The u-Healthcare is composed to u-Hospital area, home and mobile healthcare area and wellness area. The u-Hospital area deals efficiency and easiness of hospital. The home and mobile healthcare area covers the affairs outside the hospital. Wellness area promotes general healthcare and health information for anyone. Current u-Healthcare concentrates on the treatment and recuperation. But further u-Healthcare concept will concentrate intensive healthcare and specialize to the wellness such as disease prevention, and the Wellness-Care will be the main issue of the future u-Healthcare service [5].

III. Multi-purposes U-Healthcare System Design

The u-Healthcare system would be designed for its own purpose and implemented as an individual system or several function group of healthcare system. Almost u-Healthcare system also provides a server system to maintain or analyse the periodic healthcare data. In the area of u-Healthcare system, the communication method between sensor client and server system would be very important and it is close to the body area network that provide local biomedical signal measurement system around a body to support healthcare information system[2],[6]. In this work, we used zigbee communication network and protocol among the sensors and collector to measure the healthcare data such as ECG (Electrocardiogram), BP (Blood Pressure), BC (Body Composition), HR (Heart Rate) and BT (Body Temperature). The zigbee based healthcare measurement system makes low-cost short range communication links from the sensor module to the collector instead of high-cost healthcare equipments, and gives easiness and mobility. An android smart device also adds mobile computing power for data processing and connecting server system over the zigbee links and WiFi network. The server system holds the measured u-Healthcare data sent from the android and retrieves the saved data at anytime, anywhere on the android smart device. Fig. 1 shows the zigbee based u-Healthcare measurement system.

In this paper, we designed zigbee sensor modules, zigbee collector and android application program. The zigbee sensor module was designed to connect with various sensor units such as ECG pad, current electrode or other sensor products. It also includes MPU, ADC and zigbee communication module. Any zigbee sensor module can measure the analogue signal and convert to the digital data and send it via zigbee network. All digitized data send to the zigbee collector installed in the android smart device's microSD memory socket. The collector sends data to the android application program to analyse and finally shows up the results on the screen or send to the server system. Basically, the zigbee sensor module and the zigbee collector use the same MPU module and zigbee chip. They also have built-in embedded program for basic action and control functions in their internal memories.

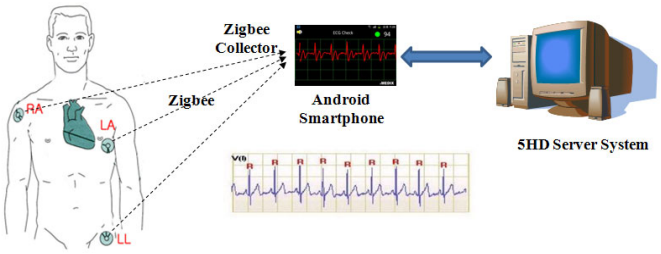


Fig. 1 Zigbee based u-Healthcare measurement system

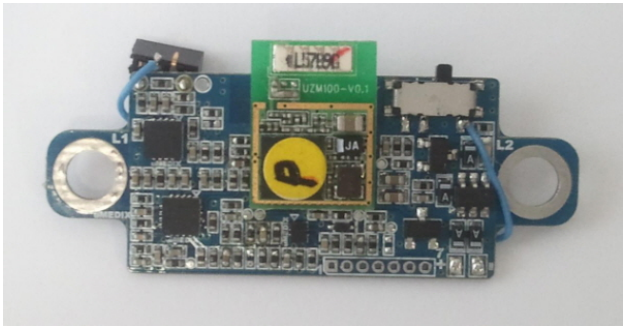
IV. System Implementation and Results

The zigbee based multi-purposes u-Healthcare system was implemented and cooperated with Umedix Co. as a small, lightweight mobile system based on the smart mobile device such as smart phone or smart pad. It includes zigbee sensor module, zigbee collector and android application program as follows.

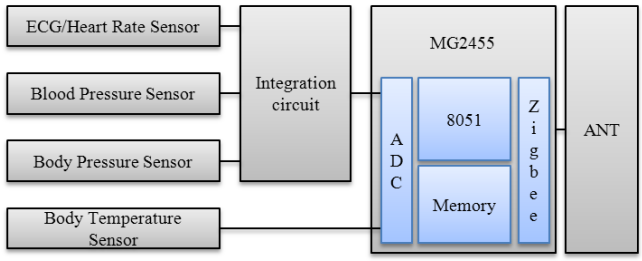
A. Zigbee Sensor Module(SENIC) and Collector

The zigbee sensor module developed by Umedix Co. provides u-Healthcare data and called SENIC as product name. It can be connected with sensor pads, air-pressure sensor, electrode, temperature sensor or any other electric sensor units and driven by battery. The SENIC includes series of OP amps integration circuit connected to each sensor unit, MG2455 microchip that has 8 bit MPU, 8bit ADC, zigbee

communication as shown in Fig. 2 that is programmed by ICE (In-Circuit Emulator). The microSD typed zigbee collector developed by Radiopulse Inc. is also programmed to cooperate with SENICs single or multiple links through the zigbee network protocol [7]. At the case of ECG measuring, at least 3 SENICs form 3 links. The BC uses 2 SENICs, and BP, HR, BT just uses only one SENIC and forma single zigbee communication link. When the collector establishes one or more links, the android application program of ME (Mobile Equipment) would get the u-Healthcare data from the collector sent over the SENIC(s) and process or analyse the data for appropriate result. Fig. 3 shows the entire system architecture including SENICs, collector and android application program.



(a) Photograph of SENIC



(b) Block diagram of the SENIC

Fig. 2 Experimental version of SENIC

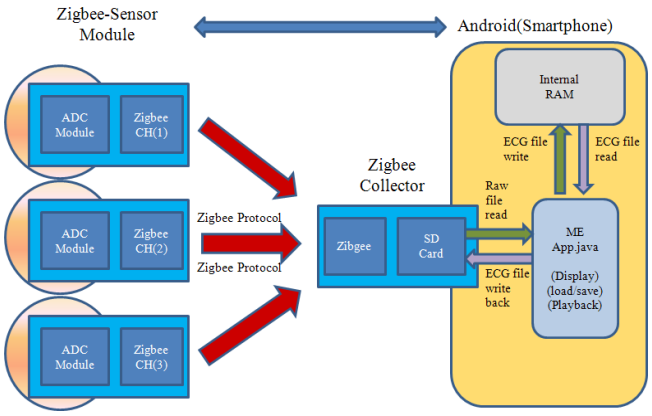


Fig. 3 Zigbee sender module (SENIC), zigbee collector and android app architecture

B. *Android Application Program*

Android application program (App) called IMU interfaces the zigbee network and u-Healthcare service user through android smart mobile device. The app receives u-Healthcare data from the zigbee collector and processes data to show up the result in real time on measuring activity or to save results in data history activity. The app also send the data history to the dedicated u-Healthcare server system through WiFi network at every end of a measurement or at a specific moment as a bunch of data accumulated daily and weekly based intervals. A series of SQL database commands are committed in the app over all data processing for internal database actions and SQL server activities [8].

The app we implemented in this work includes two main activities for measuring data and data history management. Each activity has its own interfaces for each u-Healthcare data. Fig. 4 shows the software stack of the app.

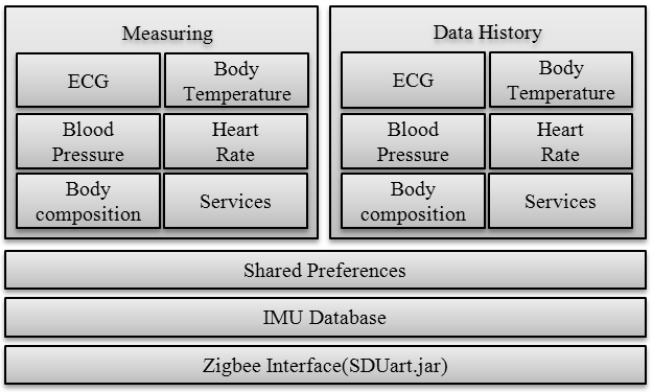


Fig. 4 Android app software stack

1) *Measuring Activity*

The measuring activity gives interfaces to measure the u-Healthcare data including ECG, BP, BC, HR and BT as shown in Fig. 5(a). Lifestyle, weight, glucose and service items are not included in the scope of this work since they need not use the SENIC. Each interface provides specific measuring and calculating method via sub-activities and threads connected with the specific SENICs.

(a) ECG(Electrocardiogram)

The ECG signal can be formed as a sum of signal comes from the 3 ECG SENICs positioned on the LA, RA and LL [9-11]. It can be plotted as a graph in real time as shown in Fig. 6(a). It shows signal level, R-R interval and visual heart rate.

(b) Blood Pressure

Blood pressure SENIC has a kind of air-pressure sensor with cuffs and gives relative blood pressure value to the BP interface [2]. It plots BP data in real time and calculates the systolic and diastolic values by using built-in reference values as shown in Fig. 6(b).

(c) Body Composition

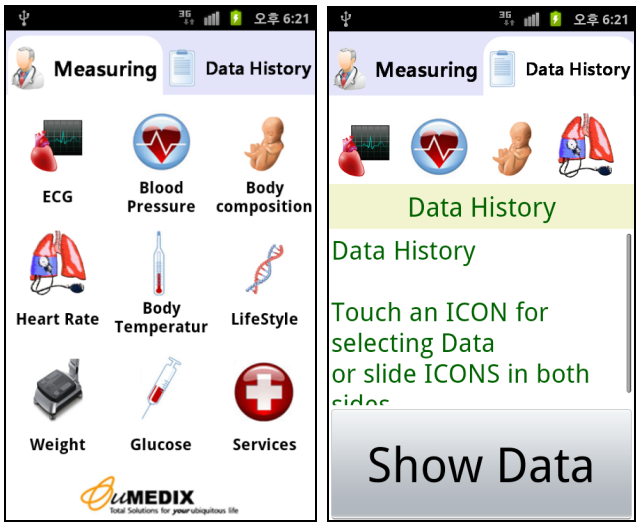
Body composition can be measured with two SENICs that apply weak current between two body positions and get a current difference between the SENICs. The BMI can be calculated from the current difference with user's height, weight and gender and pointed on the health position graph as shown in Fig. 6(c) [2].

(d) Heart Rate

Heart rate can be calculated as the same method of ECG. From the ECG data, an average R-R interval can be calculated and we can derive the HR from the R-R interval [10]. The interface shows HR action and HR value as shown in Fig. 6(d).

(e) Body Temperature

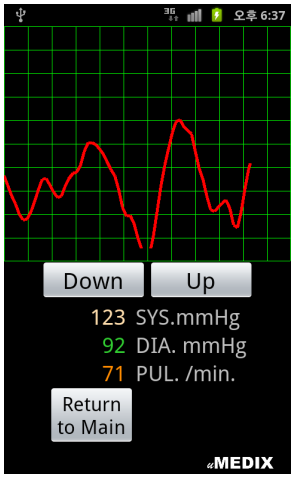
Body temperature shows the digital value of LM60 temperature sensor directly through the SENIC [12]. The BT value steps in 0.5 degree as the body temperature variation as shown in Fig. 6(e).



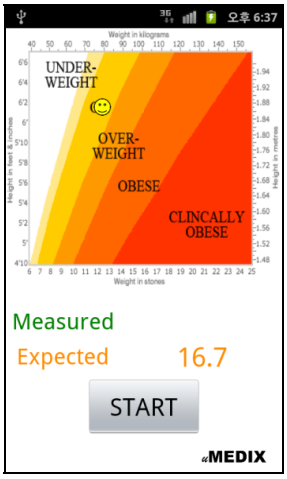
(a) (b)

Fig. 5 Main Activities: (a) Measuring (b) Data History

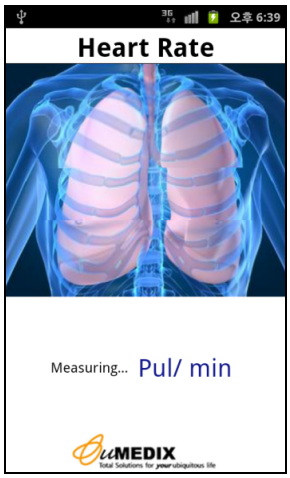
(a)



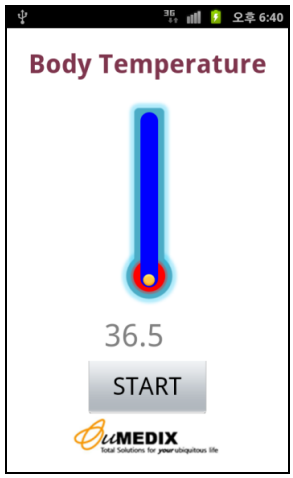
(b)



(c)



(d)



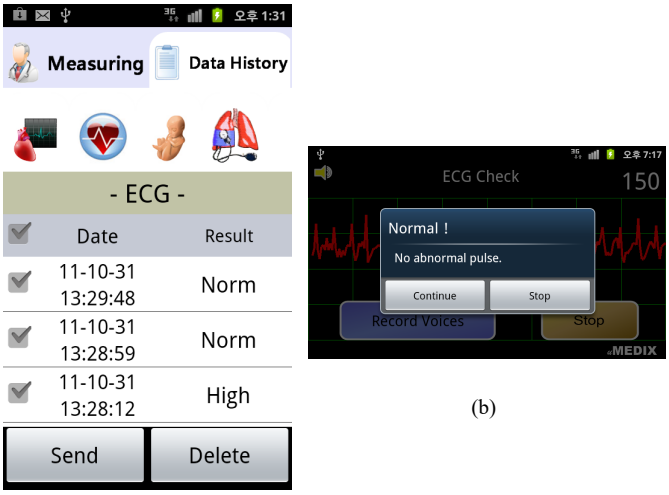
(e)

Fig. 6 Measuring Activities: (a) ECG (b) Blood Pressure (c) Body Composition (d) Heart Rate (e) Body Temperature

2) Data History Activity

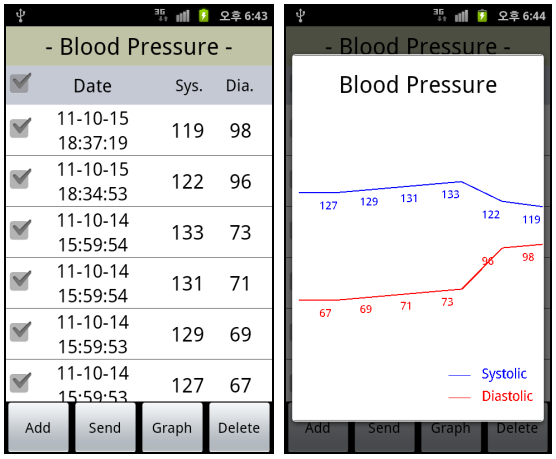
The data history provides previous data accumulated at every end of data measurement as shown in Fig. 5(b). Each u-Healthcare data can be maintained in memory of android daily and weekly based. Accumulated data can be listed as a series of measured and analyzed result and can also be plotted as a graphical form.

All data history maintains its own data format of MS-SQL. The data history interface can access any data through SQL query and shows the access results as a form of text or continuous graph on the result interface. Fig. 7 shows an example of ECG data history and ECG data re-player the same as ECG measurement skin. Fig. 8 and Fig. 9 show examples of the data history as a case of blood pressure and heart rate. The body composition and body temperature has the same data history interface as blood pressure with the same database and the same type of shared preferences to share the common data such as user name, height, weight, date and time.



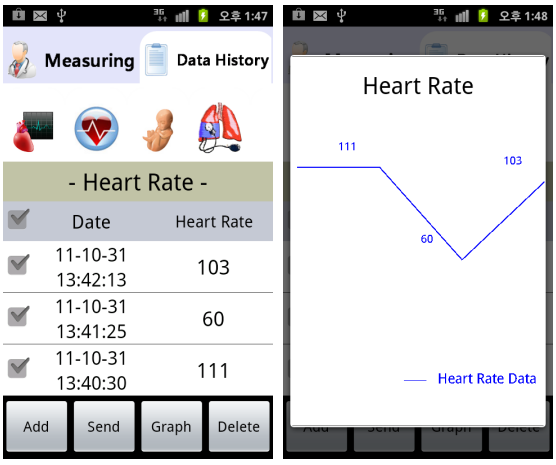
(a) (b)

Fig. 7 ECG Data History: (a) Measured ECG data list (b) ECG re-player



(a) (b)

Fig. 8 Blood Pressure Data History: (a) Measured data list (b) Graphical data activity



(a) (b)

Fig. 9 Heart Rate History: (a) Measured data list (b) Graphical data activity

V. Conclusions

In this work, we had designed and implemented a new multi-purposes u-Healthcare service system that can gives easiness and mobility by using zigbee network includes our own zigbee sensor modules for ECG, BP, BC, HR and BT data measurement, zigbee collector and android application program. Each zigbee sensor module sends a specific healthcare data to the collector. The zigbee collector receives all healthcare data from sensor modules and drives up to the android application program. The android application program analyses the healthcare data and shows up the result in real-time measuring or data history interfaces.

This multi purposes u-Healthcare service system can mix the merits of the zigbee network and smart mobile device, and can gives more easiness and mobility under the current ubiquitous environment than other mobile healthcare system with low cost. But the zigbee based network system would have some problem on the network robustness on heavy data traffics such as ECG. If there is insufficient data buffering mechanism over the sensors and collector communication, some data loss and re-transmission should be required that slows down the zigbee network performance. Further research will be concentrated on the least data packet loss among the zigbee sensor modules and collector through the appropriate data buffering mechanism optimized on the simultaneous multiple U-Healthcare data stream.

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