집적형 IEEE 802.15.4 무선 모바일케어 응용시스템의 설계 및 적용

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Design and Implementation of Integrated IEEE802.15.4 Wireless Mobile Care Application

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요 약

무선컴퓨팅에서의 최근 동향은 모바일능력을 향상시키고, 응용범위의 필요성에 적합한 새로운 접근 방법을 개발하는데 초점이 모아지고 있다. 이 논문은 환자의 무선의료 소자로부터 무선으로 데이터를 받고 반응하고 그 셀룰러 네트워크를 활용하여 의료센터로 보내는 기능을 가진 IEEE802.15.4 무선 CDMA기반의 헬스케어 시스템에 관한 것이다. 모바일 응용시스템은 무선센서네트워크와 셀룰러 네트워크사이에서 의료데이터를 받고 보내는 것을 조절하는 미들웨어 뿐만 아니라 위치에 상관없이 휴대전화로 환자의 헬스상태를 연속적으로 모니터링하고 분석하는 인터페이스를 제공한다. 따라서 이 시스템은 원격 헬스모니터링을 가능하게 하고 IEEE802.15.4 무선네트워크와 병원이외의 지역에서의 CDMA 네트워크사이에서 원격 헬스모니터링과 끊김없는 메디컬데이터 연결을 제공한다.

ABSTRACT

Recent generation of wireless computing has focus on the integrating of exisitng technologies to enhance the mobile capabilities and developing a new approaches to meet the needs of the growing pool of applications. This paper describes an integrated IEEE802.15.4 wireless CDMA based healthcare system that interacts and received the data wirelessly from wireless medical devices of patient and forward to medical center by using the cellular network. Mobile application had been developed not only as the middle ware to handle the receive and transmit of medical data between wireless sensor network and cellular network but also provides the interface for monitoring and analyzing the health condition of patients continuously at cellular phone regardless of its physical location. This system thus enables the remote healthcare monitoring and supports medical data seamlessly roams between IEEE802.15.4 wireless network and CDMA network beyond and outside the hospital environment.

Keyword

IEEE802.15.4 wireless network, CDMA network, mobile healthcare monitoring application

I. Introduction

The development of network technology has prompted and permitted sensor folks to consider alternatives that reduce cost and complexity, improve mobility and reliability with tiny sensor device in wireless data communication. Along with the increased number of patients from year to year, many hospital are trying hard to shift from an in-patient to outpatient basis whenever possible to solve the problem of insufficient of hospital beds and medical services. This thus has motivated the many new invent of remote or in-home monitoring healthcare application (eg.[1]) to improve efficiency and quality of patient care.

Recent innovation technologies such as mobile computing devices has been increasingly integrated into the healthcare environment and work together to create a reliable and secure communication backbone to allow access to vital information anytime at anywhere. The capability of integrating the wireless network and cellular network to create a well-established quality, wide coverage communication range, high mobility and enhanced QoS heterogeneous for wireless computing application has given us ideal to develop integrated IEEE802.15.4 wireless CDMA based mobile healthcare application to provide the healthcare solution to the patient whenever the cellular network is available.

II. System Overview

2.1 Objective

The goal of this system is to develop the concepts and tools for offering wireless mobile healthcare services. Constantly and remotely delivering access to clinical application at patient point-of-care helps to improve the quality of care. By adding wireless technology to elimininate handwriting and paper records can anticipate a reduced number of medical errors. Continue monitoring and diagnosing vital signs locally helps to reduce the relapse rate, overall hospitalization cost and period.

2.2 Architecture Design

System has adopted the mobile computing and utilized the IEEE802.15.4 enabled medical devices to empower the mobile caregivers the mobility accessing to vital information, deploy the patient care in a cost-effective manner by leveraging a merged infrastructure of IEEE802.15.4 network and CDMA network. Figure 1 depicts the system architecture design which composes of three main parts: Sensing units, communication infrastructures and healthcare management.

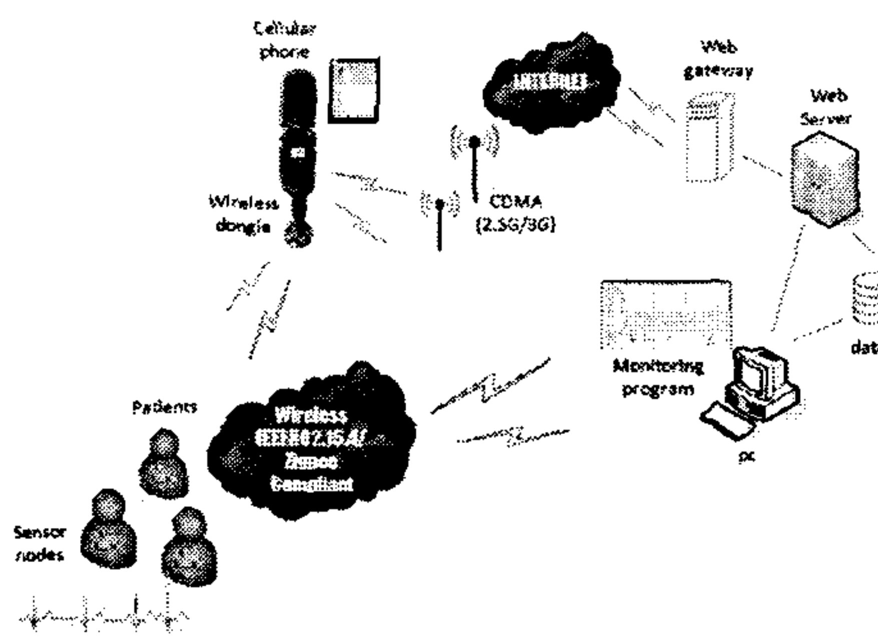

Figure 1. System Architecture.

2.1.1 Sensing Unit

The sensing units includes wearable tiny IEEE802.15.4 enabled devices such as body sendor node or chest belt which aggregates and transmits the collected vital signs to server beyond the hospital or to wireless dongle prototype and then relay to hospital through cellular network.

Table 1. Hardware specification

MCU	MSP430F1611
RF Transceiver	CC2420
Bandwidth	2.4GHz
RF Range	≈100m
Power	2.5V ~ 4V(battery or cellular phone)

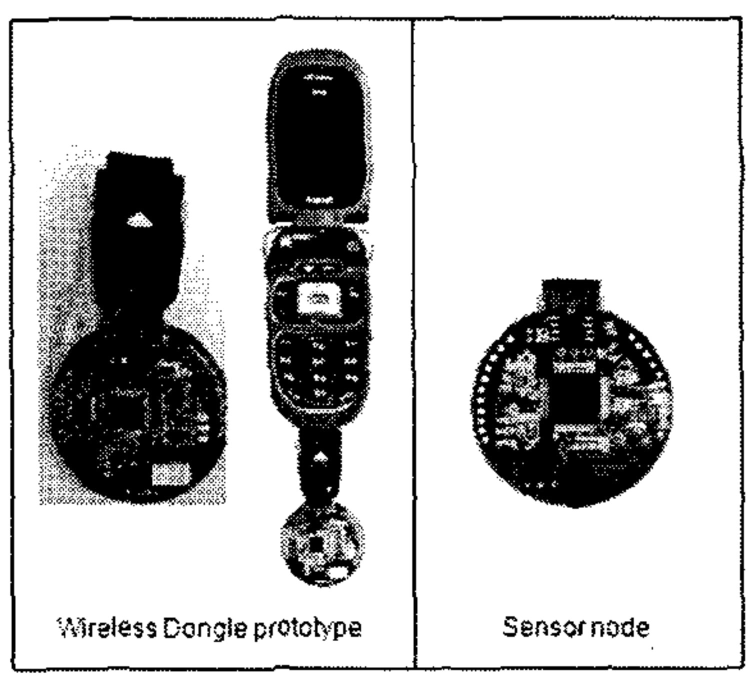

Figure 2. Developed wireless dongle prototype and the fabricated sensor node.

Table 1 summarizes the hardware specification that used to develop fabricated sensor node. The size of the fabricated sensor node is 4 x 4 x 0.2 cm. The fabricated sensor node can be used to further integrated with other sensors to become IEEE802.15.4 enabled medical (wireless dongle prototype) that connectable to the cellular phone to aggregate data from patient. Figure 2 show the developed wireless dongle prototype and fabricated sensor node.

2.1.2 Communication Infrastructure

The envisaged new generation has emphasized the combined different networks as the newly protocol to meet the needs of the current application requirements. In this system, we deployed a protocol that integrates IEEE802.15.4 network and CDMA network to enable medical route from patient at home or outside hospital to hospital through cellular network. Cellular phone interacts and receives vital signs from IEEE802.15.4 enabled medical device through RS232 interface and relays it to hospital through TCP/IP layers.

Table 2. RS232 Configuration Setting

Comm Port	1
Baudrate	57600
Parity	None
Size	8 bits
Flow	None

Table 2 shows the RS232 configuration setting between wireless dongle and cellular phone. The developed mobile application will deploy the request and respond method to relay the data to web service through TCP/IP protocol. *Http post* is used where the data will be wrap into the XML format and send to webservice. Cellular phone then receives and process the respond XML format to get the correct data.

2.1.3 Healthcare Management

The healthcare management part includes the mobile healthcare application and server monitoring application]. Mobile healthcare application is developed provide continue self-monitoring and analyzing of patient locally and to handle the message passing between IEEE802.15.4 network and CDMA network to enable the hospital based in-patient care to be shifted to out-patient care whenever the cellular network is available.

III. Mobile Healthcare Application

3.1 Application Flow

Figure 3 diagrams the system flow chart for the mobile healthcare application. A simple ECG monitoring program is implemented to enable patient to continue monitoring and *diagnosing their health condition locally at* home or travel environments. Upon any suspicious or unknown ECG signals, cellular phone *will relays the data to the* Server and further analyze by the server monitoring program.

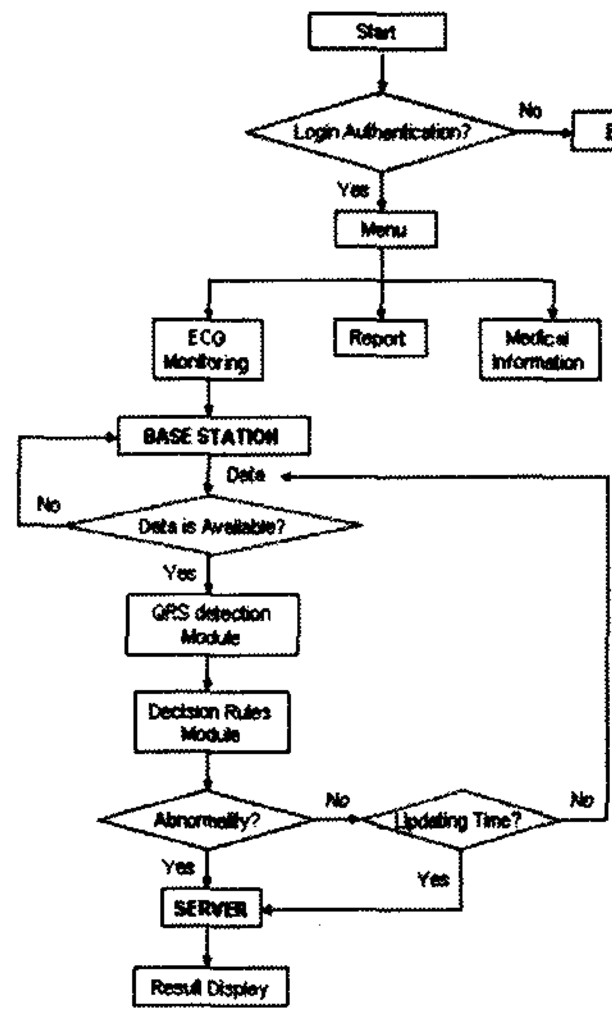

Figure 3. Mobile application flow chart

3.2 ECG Analyzing Module

The ECG analyzing module includes two sub-modules which are QRS detection module and decision rule module. The QRS detection sub module is developed based upon the Pan-Tompkin QRS detection algorithm [2]. It consists of a band-pass filtering, derivative, squaring and moving window integrator stages. Band-pass filtering uses cascaded filters of a low pass (1) that cut-off frequency at about 12 Hz and high pass (2) that cut-off frequency at about 5Hz. The gain for low pass is 36 with filtering processing delay of 6 samples and 32 for high pass with filtering processing delay of 16 samples. The derivative (3) helps to obtain the slope of the QRS. Squaring (4) process intensifies the slope of the frequency response curve obtained from of the derivative stage and restricts false positive. Lastly moving window integrator (5) produces a signal that include the information about the both slope and width of the QRS complex.

$$y[nT]=2y[nT-T]-y[nT-2T]-2x[nT-6T]+x[nT-12nT] \quad (1)$$

$$y[nT]=y[nT-T]-x[nT]-x[nT-32T] \quad (2)$$

$$y[nT]=\frac{2x[nT]+x[nT-T]-x[nT-3T]-2x[nT-4T]}{8} \quad (3)$$

$$y[nT]=[x(nT)]^2 \quad (4)$$

$$y[nT]=\frac{1}{N}[x(nT-(N-1)T)+x(nT-(N-2)+...+x(nT)]^2 \quad (5)$$

T: Sampling Interval
N: Width of window

The decision rule sub module is to calculate the heart rate and determine the normality of the ECG signal. Any signal that has window width less than 100ms with R-R interval between 0.8s and 0.9s or window width less than 60ms with the R-R interval greater than 1.1s is considered normal signal. Otherwise, it will classify as abnormality and the ECG signs will be relayed to Server for further evaluated.

Ⅳ. Experimental Results

In this section, we conducted a real-time ECG test beds that includes real human body and ECG generator to simulate sample records from MIT/BIH arrhythmia database. Figure 4 illustrates the ECG testbed set up which data is collected to wireless dongle prototype, analyzed at cellular phone and then relayed to the Server upon abnormality detected.

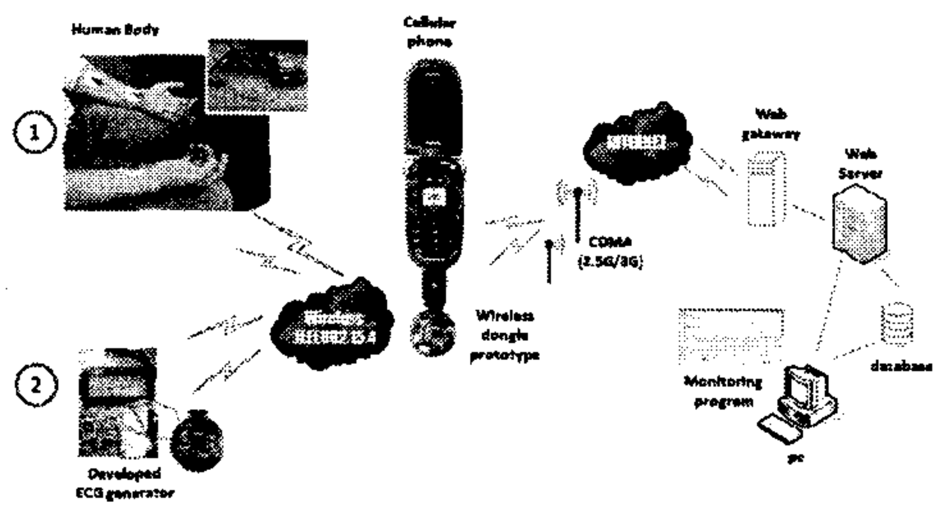

Figure 4. ECG test bed set up.

Figure 5 presents the results screen capture of cellular phone (a-b) and server monitoring application (c) of the ECG signal received through CDMA network. Doctors and patients might have different authority to access to the information where it provides doctors more information of the ECG signal includes R-R interval time, R-R interval peak, QRS interval time and etc. The establishment connection between cellular phone and server is varied corresponding to the signal strength of the cellular network which may take average time about 8 to 12seconds.

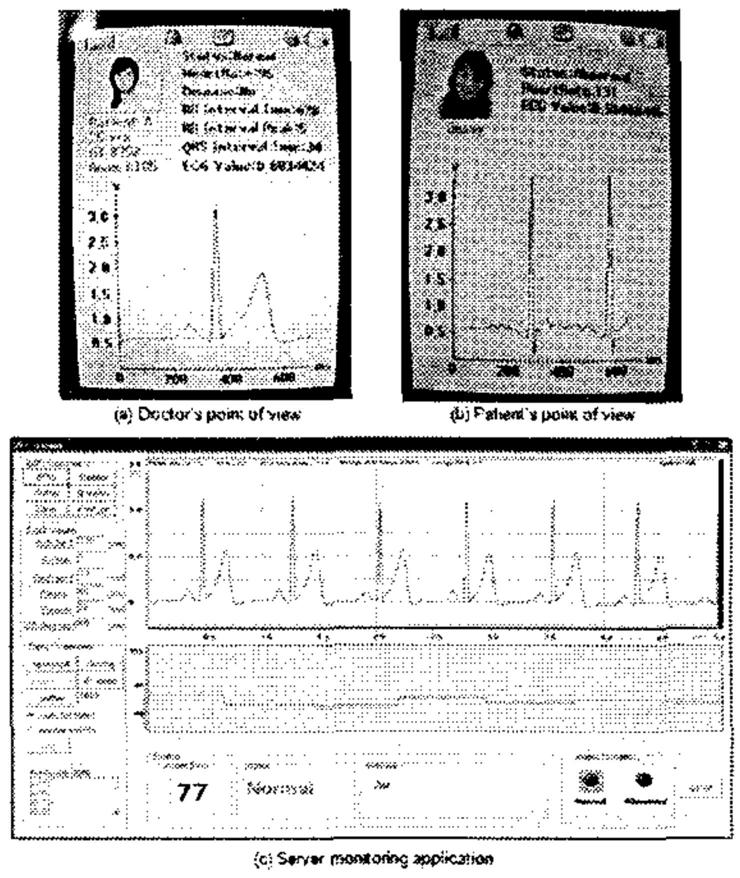

Figure 5. Cellular phone screen capture results (a-b) and server monitoring application (c).

Ⅴ. Conclusions

By integrating the IEEE802.15.4 network and CDMA network helps to create a wider communication range and improved capacity for the application. This system has permitted heathcare from hospital in-patient basis to be shifted to out-patient basis which has reduced the overall hospitalization cost while also improve the quality of the patients.

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