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Healthcare Monitoring System Using Wireless Sensor Network

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ABSTRACT

Using Wireless Sensor Networks (WSNs) in health care system has yielded a tremendous effort in recent years. However, in most of these researches, tasks like sensor data processing, health state decisions making and emergency messages sending are completed by a remote server. Transmitting and handing with a large scale of data from body sensors consume a lot of communication resource, bring a burden to the remote server and delay the decision time and notification time. In this paper, we present a prototype of a smart gateway that we have implemented. This gateway is an interconnection and services management platform especially for WSN health care systems at home environment. By building a bridge between a WSN and public communication networks, and being compatible with an onboard data decision system and a lightweight database, our smart gateway system is enabled to make patients' health state decisions in low-power and low-cost embedded system and get faster response time o the emergencies. We have also designed the communication protocols between WSN, gateway and remote servers. Additionally Ethernet, Wi-Fi and GSM/GPRS communication module are integrated into the smart gateway in order to report and notify information to care-givers.

Keywords: GSM, Health Monitoring, Signal Processing, Wireless Sensor Networks.

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1. INTRODUCTION

Current health care systems are structured and optimized for reacting to crisis and managing illness are facing new challenges: a rapidly growing population of elderly and rising health care spending. Restructuring healthcare systems toward proactive managing of wellness rather than illness, and focusing on prevention and early detection of disease emerge as the answers to these problems. Wearable systems for continuous health monitoring are a key technology in helping the transition to more proactive and affordable healthcare. Recent technology advances in integration and miniaturization of physical sensors, embedded microcontrollers and radio interfaces on a single chip; wireless networking; and micro-fabrication have enabled a new generation of wireless sensor networks suitable for many applications as shown in Fig. 1.

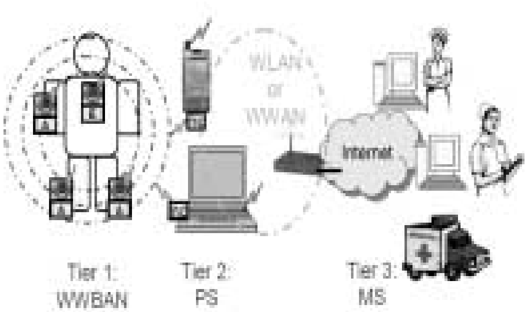

Fig. 1 Block Diagram of WSN

Smart environments represent the next evolutionary development step in building, utilities, industrial, home, shipboard, and transportation systems automation. Like any sentient organism, the smart environment relies first and foremost on sensory data from the real world. Sensory data comes from multiple sensors of different modalities in distributed locations. Because of the numerous advantages of Wireless Sensor Networks (WSNs), which include wide coverage, low cost, low power, self-configuration and real-time data access, WSNs have been used in various areas such as military, natural disaster prevention, wildlife tracking system and health care monitoring. In order to meet the Quality of Service (QoS) in different applications, varieties of communication protocols are needed to bridge WSNs with required networks. In this paper, we have designed an efficient communication protocols to bridge WSNs with public network (Ethernet, Wi-Fi and GSM/GPRS) to establish communication between WSNs and remote server. WSNs in health care system which integrates wireless communications, health care and sensor network, have attracted a lot of research efforts in recent years [1][2][3]. A WSN health care system usually consists of three parts: body and home environment sensors network, access devices including a gateway and public communication networks, and care-givers such as remote central server, doctors and relatives. A scenario is shown in Fig. 1. Main role of the gateway is to bridge the WSN with public communication network. Usually, sensor networks which are compatible with IEEE 802.15.4 and run on the 868/916MHz or 2.4GHz ISM frequency bands cannot communicate directly with public communication networks which operate on Ethernet, IEEE 802.11 or GSM/GPRS networks. So gateway is

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needed to work as protocol translators, impedance matching devices and rate converters between them.

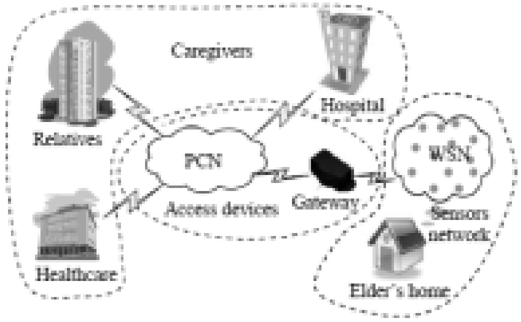

Fig. 2 Architecture of WSN Healthcare System

Most of the past health care system research efforts were focused on sensor networks design like routing, MAC design, and sensor nodes deployment. In those designs, sensor data are transmitted to remote server through access devices. Tasks like sensor data storage, patients' health states determination, and notifications are conducted by a central server while gateway only acts as an intermediate device. The response delay includes network delay and central server delay. In health care system, WSNs provide a large quantity of real-time signals which should be processed in time. With the increase number of patients, central server's processing time will increase rapidly. The long distance data transmission may also cause problems, such as congestions and packet losses. With the advances in electronics technique, current embedded systems have much faster processor and bigger memory. This allows the gateway to have the ability to complete some more complex works and to interconnect to different kinds of public networks. To solve the problems above, we have designed a gateway-centered WSN health care system. In this gateway, some tasks are moved to the gateway to reduce the burden of remote server and public network traffic.

In this paper, the hardware and software has been designed with the WSN and a remote server. An on-board Data Decision System (DDS) has been designed to make a decision of the health states of the elderly according to the sensing data from sensor nodes. A low resource requires and high efficient database is designed for this system. Furthermore an Ethernet module is implemented to communicate with remote server and a GSM/GPRS module for sending emergency messages.

2. WIRELESS SENSOR NETWORK

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices that use sensors to monitor physical or environmental conditions. These autonomous devices, or nodes, combine with routers and a gateway to create a typical WSN system. Sensor networks are the key to gathering the information needed by smart environments, whether in buildings, utilities, industrial, home, shipboard, transportation systems automation, or elsewhere. Recent terrorist and guerrilla warfare countermeasures require distributed networks of sensors that can be deployed and have self-organizing capabilities. In such applications, running wires or cabling is usually impractical. A sensor network is required that is fast and easy to install and maintain. The smart gateway is designed to enable WSN and public communication networks to access each other with seamless internetworking. In this design, the gateway consists of central control unit, database (DB), WSN module, WLAN AP, and GSM module, as shown in Fig. 3.

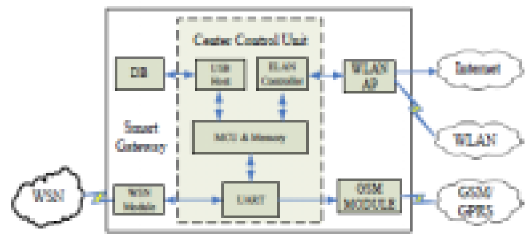

Fig. 3 Structure of Gateway

The distributed measurement nodes communicate wirelessly to a central gateway, which provides a connection to the wired world where the data can be collect, process, analyze and present your measurement data. To extend distance and reliability in a wireless sensor network, you can use routers to gain an additional communication link between end nodes and the gateway. The gateway includes three external communication modules (ECM): WSN Module, WLAN AP, and GSM Module. WSN module, on one hand, is mainly used for receiving data packages from the sink of the WSN; on the other hand, it is used to send commands to the WSN or specific sensor nodes. It implements the protocol translation and provides the physical mechanism between gateway and WSN.

In this design, a MIB520 USB Interface Board attaching with the sink node in WSN is used as the WSN module. A GSM module is needed when sending SMS to the care-givers using GSM networks, or sending data to remote server through GPRS if necessary. In this design, the GT64 terminal of small size is selected and it has low power consumption [9]. GT64 is an intelligent GSM/GPRS control terminal which joints GSM networks with the 1800/1900 MHz RF bands. The communication can be realized via SMS over GSM or SMS over GPRS using standard AT commands. With its intrinsic TCP/IP stack, GT64 enables the gateway to access to IP connections via GSM network. WLAN AP has two tasks. First, in order to connect to the internet, it acts as a client PC and accepts the IP address assigned by the internet server. Second, it sets up an ad-hoc network for care-givers and system maintainers so that they can connect to the smart gateway with laptop or PDA easily.

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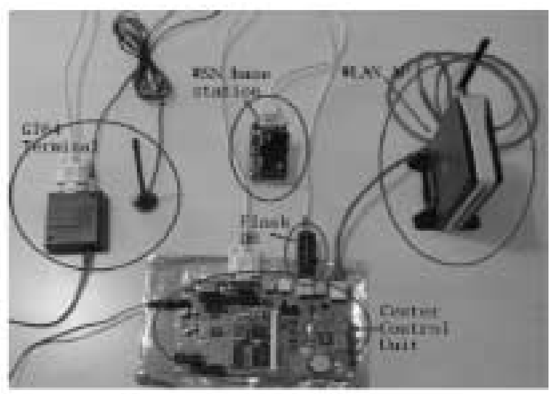
3. EXPERIMENTAL SETUP

A sensor node was attached with one sensor or several different types of sensors. A co-researcher was wearing a heart beat sensor. Normal heart beat rate was defined between 60 and 100 per minute in these tests. The smart gateway is shown in Fig. 3. The normal report cycle time was set to one minute. GT64 was set to require the SMS server to send a confirm acknowledgment when the SMS was received by the target. A time counting program was plugged into the gateway to count the delay time of Ethernet data packages and SMS transmissions. The time counting result was saved in an onboard file. The remote server was connected with gateway via the local area network. Simulator software was built up in remote server to show the experiment results, and send ACKs/requests to the gateway. A 16GB flash memory was plugged in as external DB.

We developed two custom boards specifically for health monitoring applications, an ISPM and an IAS (Intelligent Activity Sensor). The ISPM board extends the capabilities of Telos by adding two perpendicular dual axis accelerometers, a bio-amplifier with signal conditioning circuit, and a microcontroller. The ISPM's two ADXL202 accelerometers cover all three axes of motion. One ADXL202 is mounted directly on the ISPM board and collects data for the X and Y axes. The second ADXL202 is mounted on a card that extends vertically from the ISPM and collects acceleration data on the Z axis. The user's physiological state can be monitored using an on-board bio-amplifier implemented with an instrumentation amplifier and signal conditioning circuit. The bio-amplifier could be used for electromyogram or electrocardiogram monitoring. The output of the signal conditioning circuit is connected to the local microcontroller as well as to the microcontroller on the Telos board via the expansion connector. The ISPM has its own processor for sampling and low-level data processing, selected primarily for its compact size and excellent MIPS/mW ratio. Other features that were desirable for this design were the 10-bit ADC and the timer capture/compare registers that are used for acquisition of data from accelerometers. The microcontroller also has hardware UART that is used for communications with the Telos board. The IAS board is a stripped-down version of the ISPM with only accelerometer sensors and signal conditioning for a force-sensing resistor that can be used as a foot switch. The centre control unit of the gateway deals with data processing and provides all control logic to different modules. To implement the central control unit, the LPC 2378 development board is used which is of high performance and has rich peripherals integration. The MCU on LPC 2378 board is based on ARM7TDMI processor with maximum frequency of 266MHz and operation at low voltage of 2.7-3.3V. This development board has comprehensive set of peripherals for our gateway design, including MMC/SD/SDIO controller, Ethernet connection, a full function UART controller for WSN modules and GSM module control, two USB host controllers and a SD card interface for using external flash memory as database. After the prototype was established, a series of tests has been executed to evaluate the performance of the gateway. First the system under the situation without emergency events happen has been tested. Sensor nodes were turned on and the co-researcher stayed quietly. After one minute, the "remote server" received the normal report packet periodically from the gateway as what expected. Second, the system to test it with emergent situation has been started. When sensor nodes were turned on, the co-researcher started to do sports. As soon as his heart beat rate was over the normal range, the "remote server" received an emergence data packet and a SMS was received by the cell phone. Next, the time counting file and checked Ethernet packet delay and SMS delay reading has been recorded. The same experiment was repeated 5 times. We also repeated the similar experiments 5 times with the remote server connected through wireless area network. In all the experiments, the gateway always behaved as what expecting. Below is the sum up of the delay time which has recorded during trial tests. When remote server was connected with the smart gateway through the LAN, it took averagely 3 seconds from gateway sending an Ethernet package to remote server and receiving the ACK from the remote server. And it took approximately 2 seconds when remote server was connected with gateway through WLAN. Delay time from GT64 sending a SMS to receiving a reply was 10.84 seconds.

Fig. 4 Photo of GPRS module, WSN Module, Flash DB, Center Control Unit and WLAN AP



The medical sensor nodes are used to monitor various signals from human body, such as blood pressure, body temperature, pulse, blood sugar, oxygenation of the blood and so on. Many interfaces are reserved for the use of some new medical sensors in the future. For example, if the data of Electroencephalograms (EEG) was to collect in the future, the only work to do is to put the new EEG sensor into the reserved interface. The medical sensor node can handle the EEG sensor through the according interface as it does to the other medical sensor. Of course, in order to handle the new medical sensor node, the new software module is to be designed according to the new function of the new medical

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sensor. This system can be used at home or in hospitals to form a remote medical system among home, community and hospital. The sensors collect the data and send the collected data to the remote central server through many ways, such as RS232 which is connected to a local computer connected to internet, GSM and so on. The doctors have a possibility to review and analyze their medical data in their surgeries. And the patients can also see the doctor at home. The sensor node collects the data of the patient real-time and transmits the data to the sink node. All the application software on the sensor nodes are developed with C.

4. CONCLUSION

In this paper, a remote health care system based on wireless sensor network is introduced. This new technology has potential to offer a wide range of benefits to patients, medical personnel, and society through continuous monitoring in the ambulatory setting, early detection of abnormal conditions, supervised rehabilitation, and potential knowledge discovery through data mining of all gathered information. This system can be placed in a hospital or a patient's house, through this wireless sensor network the sensor nodes collect Some physiological indexes of the patients or monitor the running state of the medical devices and transmit the data to the sink node or the local computer. The wireless sensor network can connect to the remote central server by several means. This remote health care system has good scalability and high flexibility and may have a widely application in the community medical service system, care unit and so on. An even bigger, more widely used remote medical service system can be built by connecting the wireless sensor networks to the Internet. This thinks it is very important to serve the patients better. Certainly, some kind of special wireless sensor networks can be developed for special medical use to perfect the remote care system based on wireless sensor networks. The presented gateway-central health care system is a prototype. Tasks like sensor data database, DDS and real-time report are conducted in a low power embedded system. Hardware and software design of the gateway are presented and transmit protocols are designed for this gateway-central system. A series of experiment results show this prototype system is feasible and reliable. In the future, optimizing the interconnection by employing GPRS communication between gateway and remote server to extend the available coverage of the health care system and upgrade the DDS. Then, it may consider for integrating internet-base webpage and voice call function in the gateway. Security issues will also be considered in the future work.

REFERENCES

[1] H. Huo and Y. Xu, “An Elderly Health Care System Using Wireless Sensor Networks at Home”. 3rd International Conference on Sensor Technologies and Applications. Sensor comm, pp.158-163, 2009.

[2] D. Benhaddou, M. Balakrishnan, and X. Yuan, “Remote Healthcare Monitoring System Architecture using Sensor Networks”, Region 5 Conference, July, 2008 IEEE, dio: 10.1109/TPSD.2008.4562760.

[3] J. Choi, S. Yoo, H. Park, and J. Chun, “MobileMed: A PDA-Based Mobile Clinical Information System”. Information Technology in Biomedicine, IEEE Transactions. Volume 10, Issue 3, pp. 627 – 635, July 2006.

[4] L. Wu, J. Riihhjärvi and P. Mähönen, “A Modular Wireless Sensor Network Gateway Design”. Communications and Networking in China, 2007 CHINACOM '07. Second International Conference pp. 882 – 886, Aug. 2007.

[5] M. Zuniga and B. Krishnamachari, “Integration Future Large scale Wireless Sensor Networks with the Internet”, USC, Computer Science Technical Report 03-792, 2003.

[6] S. Oh and C. Lee, “u-Healthcare SensorGrid Gateway for connecting Wireless Sensor Network and Grid Network”. Advanced Communication Technology, 2008. 10th International Conference, Volume: 1, pp. 827-831, Feb. 2008.

[7] S. Schleinkofer, “HMM Based Activity Recognition of Elderly at Home using Wireless Sensor Networks”. Finial thesis of engineer school of Jönköping University, 2008.

[8] L.R. Rabiner, “A Tutorial on Hidden Markov Model and Selected Application in Speech Recognition”, Proceedings of the IEEE, Vol. 77, Issue 2th, Feb, 1989. pp 257-286.

[9] “GT64 Quadband GSM/GPRS Terminal/Modem”,http://www.cepag.com/cep_telit-products/products/gprs-umts terminals/gt64/gprs_terminal_gt_64.html.

[10] A. Cerpa, J.Wong, L. Kuang, M. Potkonjak, and D. Estrin, Statistical Model of Lossy Links in Wireless Sensor Networks, IPSN, April 2005.

[11] Smart Transducer Interface Standard, IEEE 1451, Sensors Expo, Philadelphia, Oct. 2001.

[12] P.R. Kumar, “New technological vistas for systems and control: the example of wireless networks,” IEEE Control Systems Magazine, pp.24-37, 2001.

[13] IEEE 1451, A Standard Smart Transducer Interface, Sensors Expo, Philadelphia, Oct. 2001

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