

Development of u-Healthcare System Based on Ubiquitous Networks

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Abstract

In this paper, we are study conducted on the u-Healthcare system that can transmit a patient's emergency situations and location information at the same time as it is embedded with diverse sensors to detect emergency through a patient's bio signals examined.

The system herein developed for the research is portable to detect a patient's emergency situations, and can sense his or her pulse, body temperature, and location information to transmit to hospital server through wireless network, and offer real-time location identification service for staff and medical appliances through kiosk installed in major locations in a hospital. For a network to transmit wireless data generated from a patient's portable end terminal to hospital server, used was Zigbee, inexpensive mesh network, rather than high-end WLAN to accommodate the whole area of hospital to compose wireless network. Communication within a configured wireless network is connected to TTL and UART to communicate and it is configured so that IP selection is possible for WLAN Card Adapter. Through this, a system was configured so that the patient and elderly people are able to transmit the vital and location information to the hospital system. A network that is necessary for transmitting the wireless data generated by the handheld device carried by the patient to the hospital server was configured using ZigBee which is a cheaper mesh network compared to the high cost WLAN in order to cover the entire hospital.

Keywords: *u-Healthcare, Mesh network, Location-aware, Wireless sensor network, USN*

1. Introduction

With developed wired and wireless telecommunication technology, research is being conducted to offer effective service using this. Particularly, one of the most important interested fields is application service using USN. The USN draws attention as a core technology that enables information to be shared between objects through wireless telecommunication between sensor node and reader. Further, it can process a large amount of sensing data from heterogeneous sensor node in real time by using USN technology.

The present sensor network technology is rapidly developing with advent of diverse sensors and operating systems, and diverse application technologies using sensor network technology are being presented; out of them, a signature technology is a context awareness application adjusting movement by recognizing a context. The field of context awareness application serves as a wide variety of application service by recognizing users' location through sensor and processes location information in diverse forms, and one of the most important application fields is a health care field.

Currently, with advent of serious social problems caused by increased average life expectancy worldwide and the increasing number of the elder living alone, to resolve these problems, research is actively being conducted on overall health care service on welfare and health management policies for the elder living alone and caregivers. The health care service is being developed into u-Healthcare that encompasses a wide range of IT areas including medical appliances, end terminals, hospital-clinics network, bulk database, and application service.

The u-Healthcare makes it possible to monitor a patient's condition in a remote manner by using a wide array of medical appliances and sensors to provide health management and medical service. This enables service to be offered to even remote regions where medical service is hardly conducted, and emergency situations to be taken care of through real-time monitoring. The u-Healthcare system can offer health management and a wide range of medical service to the elder living alone not given appropriate medical service.

Thus, the research herein is conducted on the u-Healthcare system that can transmit a patient's emergency situations and location information at the same time as it is embedded with diverse sensors to detect emergency through a patient's bio signals examined.

The system herein developed for the research is portable to detect a patient's emergency situations, and can sense his or her pulse, body temperature, and location information to transmit to hospital server through wireless network, and offer real-time location identification service for staff and medical appliances through kiosk installed in major locations in a hospital.

For a network to transmit wireless data generated from a patient's portable end terminal to hospital server used was Zigbee, inexpensive mesh network, rather than high-end WLAN to accommodate the whole area of hospital to compose wireless network.

2. u-Healthcare Configuration of the Sensor System

Recently many studies are being conducted for the u-Healthcare services and for a variety of services, an active recognition algorithm utilizing 3-axis acceleration sensor, everyday activity detection algorithm utilizing a pressure sensor, providing elderly living assistance services using the elderly activity tracking technology and mobile devices and a study is being conducted for the u-Healthcare service that monitors blood sugar and electrocardiograph using ZigBee for the elderly people with diabetes or heart disease. Therefore in this study, to pace with such studies, a system was configured for sensing variety of patient's information and location information for transmitting to the hospital server.

2-1. Sensor system for the u-Healthcare

In order to gather information of patients and elderly such as pulse rate and body temperatures, sensors must be easy to fasten, should not discomfort the subject and adhesion with the wrist is required as it is located on the subject's wrist. In addition, since the wrist generates large amounts of organic electrical signal, the device must have an excellent shielding property with the characteristics of low power for portability. To meet these characteristics in this study, a piezo film sensor was used.

A sensor system using a piezo film is high precision sensor that can measure the pressure of the blood vessels and is driven by low power for excellent portability with an advantage of being able to measure the flow rate of the blood within the blood vessels during a movement. Figure 1 is a sensor configured using a piezo film which was considered in this study.

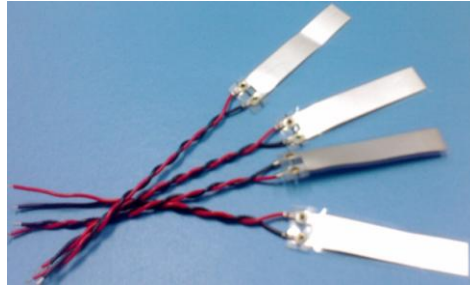


Figure 1. Piezo Film Sensor

Also as mentioned earlier, since the wrist area generates a large amount of organic electrical signal, the shielding characteristics to remove such signal is necessary. In order to achieve this, the shielding structure using a material having conductivity is shown in Figure 2.



Figure 2. Shielded Piezo Film Sensor

Since a piezo sensor has very high output impedance the sensor amplifier should use FET or OP-amp that has high input impedance and must have low power consumption and portability features. In addition, it should be able to get a high gain in the low frequency band. To meet these conditions, the sensor amplifier using LMV358M was constructed as shown in Figure 3.

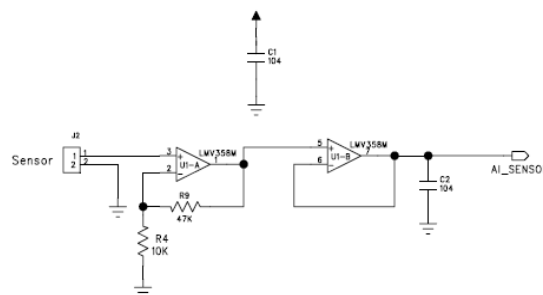


Figure 3. Sensor amplification circuit

A structure showing the stable implementation of the pulse sensor on to a wrist band is shown in Figure 4 and the configuration of the sensor with 3 elements transmitting the wrist pulse to each element.

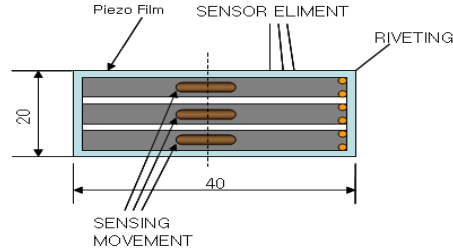


Figure 4. Internal structure of pulse sensor module

This system is for sensing the temperature and movement of the elderly patients, and the temperature sensor system considered in this study can be directly connected to the microprocessor using the IIC method and have considered a system with $\pm 0.5^{\circ}\text{C}$ reliability. In addition, in order to configure the integrated pulse sensor module small DS18B20U was used. Table 1 is the temperature data of the sensor.

Table 1. Temperature data of the sensor DS1820

Temperature	Digital Output(Binary)	Digital Output(Hex)
+125°C	0000 0111 1101 0000	07D0H
+85°C	0000 0101 0101 0000	0550H
+25.0625°C	0000 0001 1001 0001	0191H
+10.125°C	0000 0000 1010 0010	00A2H
+0.5°C	0000 0000 0000 1000	0008H
0°C	0000 0000 0000 0000	0000H
-0.5°C	1111 1111 1111 1000	FFF8H
-10.125°C	1111 1111 0101 1110	FF5EH
-25.0625°C	1111 1110 0110 1111	FE6FH
-55°C	1111 1100 1001 0000	FC90H

For the motion sensor SW-200 was used and configured so that the sensor's metal beads can measure the slope or a small vibration and the motion sensor interface circuit is shown in Figure 5.

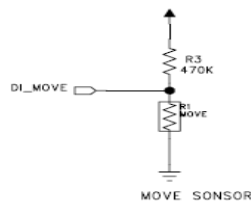


Figure 5. Interface circuit for motion sensor

The behavior of the motion sensor was configured to detect the motion status by detecting the H/L level using the input port of the processor and mounted inside the portable terminals to detect the subject's motion information in real-time basis.

2-2. Wireless sensor nodes for U-Healthcare system

A wireless sensor network is being commercialized for the wide variety of applications such as environmental monitoring, ecological research, information on traffic, agricultural production, building management and product distribution, etc. To build a wireless sensor network, a design considering the power consumption is required once the sensor node is placed in the actual environment. Therefore in this study, the MG2455 which is suitable for lower power wireless application such as home network control was selected and the wireless sensor node was configured. The MG2455 is configured having 2.4GHz RF transceiver, baseband modem, MAC hardware, 8051 MCU and internal flash memory with timer and peripheral circuits such as UART and consists of general purpose I/O pins.

Application areas consists of home automation and security, automatic meter reading, factory automation and motor control, replacement for the existing wired UART, voice applications, energy management, remote keyless entry control, low power telemetry, healthcare equipment, PC peripherals and toys.

With better features than existing ZigBee RFIC, in which general ZigBee RFIC supports data transfer rate of 250kbps, for special purposes it can be increased to 500kbps or 1Mbps. Also it supports voice codec (μ -law/a-law/ADPCM). It has high reception sensitivity of -99dBm at 1.5V and has a high RF output power of +8dBm at 1.5V. It has 8KB of data memory and 96KB of embedded flash memory for programing. It also has a deep sleep mode less than 1uA. Figure 6 is a block diagram of the MG2455 used in this study.

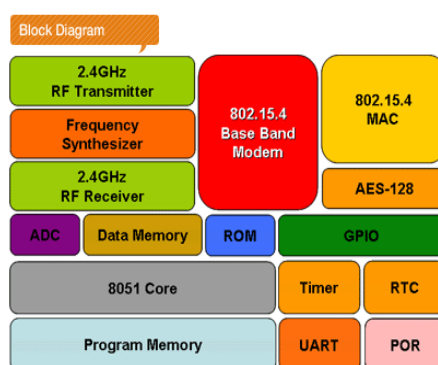


Figure 6. Interface circuit for motion sensor

The characteristics of ZigBee stack used within the ZigBee sensor node is as follows.

- Supports 65536 network nodes
- Configuration of star, peer-to-peer, clustered tree
- Network connection time of 30mSec.
- Shall have 1 network configuration with 1 coordinator and the network should consists of a number of routers and devices under the coordinator.

The configuration of the network configured using the ZigBee Stack is the same as in Figure 7 and in Figure 7, the ZigBee End Device does not participate in the network and transmits the incoming information from the sensor to the ZigBee router or the ZigBee Coordinator. The ZigBee Router transmits the data received from the ZigBee End Devices to another ZigBee Router or the ZigBee Coordinator. The ZigBee End Device consists of a star

method and the ZigBee Router consists of a peer-to-peer method where eventually ZigBee Coordinator will have a network configuration of a Cluster Tree method.

The ZigBee End Device to the sensor module, ZigBee Router to the sensor node and ZigBee Coordinator corresponds to the gateway.

The gateway connects to other networks therefore one service network can have many ZigBee Coordinators.

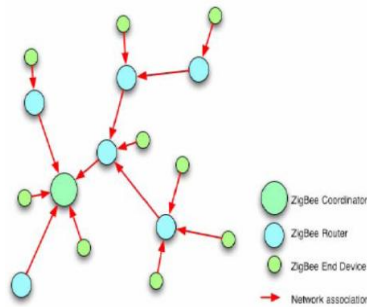


Figure 7. Composition of sensor networks

The Figure 8 shows the stack processing within the processor in order to process the data in sensor network.

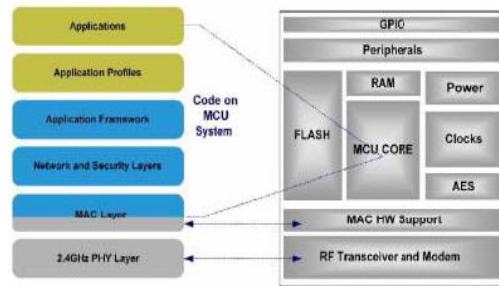


Figure 8. Stack structure in one-chip

IEEE 802.15.4 MAC sublayer was configured to use CSMA-CA(Carrier Sense Multiple Access with Collision Avoidance) algorithm to access the channel and the Figure 9 is a schematic diagram for the MAC data service.

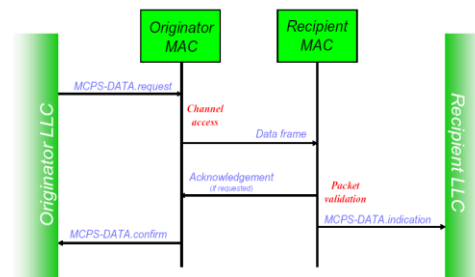


Figure 9. MAC data Service structure

The IEEE 802.15.4 MAC sublayer uses CSMA/CA(Carrier Sense Multiple Access with Collision Avoidance) algorithm to access the channel. Within ZigBee, an approach method to the CSMA/CA channel is separated into two, "CSMA/CA without slot" method and "CSMA/CA with slot usage" method. Before the data is transmitted, CSMA/CA checks for transmission from other devices within its PAN. If someone is already transmitting a data it will randomly wait for a retry. CSMA/CA uses contention method therefore the device having the first access will be transferred first. If a conflict occurs, it is a way to avoid the conflict of having the upper layer to process and it is inelegant compared to collision detection but the chip set can be implemented inexpensively with a very good features.

All devices in an attempt to transfer contains each of these three variable: NB, CW, BE. NB stands for how much back off is required while attempting the current transmission of CSMA/CA algorithm and it is reset to zero before each transfer is attempted. CW(connection window) defines the length of the access window before the transfer can be started which defines the back off period that need no channel activity. This value is initialized to 2 before each transmission and if the channel is assigned it will reset to 2. The CW variable will only be used for CSMA/CA slots. BE(back off exponent) is an exponent of back off and indicates a number of how many back off time it has waited before the equipment had attempted to assign the channel. The system without a slot or a system that uses macBattLifeExt with FALSE selection, BE is set to macMinBE value. In a system that uses a slot with selection of TRUE value for the macBattLifeExe, macBattLifeExe should be set to a value that is less than 2. If macMinBE is set to 0 in the first iteration of the algorithm the collision avoidance will not be applied. The sensor node will receive the data wirelessly coming from the mobile sensor module and retransmitting them wirelessly forming a wireless network. At this time most important roles in the sensor nodes is the RF part and the circuit diagram of a wireless sensor node configured in this study is shown in Figure 10.

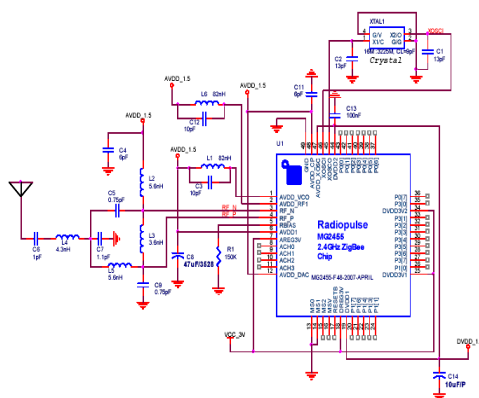


Figure 10. Circuit for wireless sensor node

The RF signal received through receive mode will go through the LNA and will be down converted to the Quadrature signal to become a baseband signal. The baseband signal after being filtered and amplified will be transferred to the modem after being converted to a digital value by ADC. The dispreading signal data in the modem will be transferred to the MAC block. During the transmission mode the buffered data from the MAC will be transferred to the baseband modem and the baseband modem after the spreading and pulse shaping signal processing will output its signal through the DAC. The baseband signal passing through the analogue Low-Pass Filter will be converted to the RF signal by the Up-conversion mixer and will be supplied to the antenna after being amplified through the PA.

3. Measuring the Sensor System for Configured u-Healthcare

The sensor for the u-Healthcare system and the behavior of the wireless network configured through this study, the individual behavior of the sensor was measured. The measurement of the piezo sensor was obtained by immobilizing the pulse sensor module onto the wrist observing the output waveform, the gain of the sensor module was set to 5~6 times and measuring the output of the wrist pulse with the oscilloscope is shown in Figure 11. As shown in the waveform on the oscilloscope picture it shows an appearance of a waveform depending on the pulse.

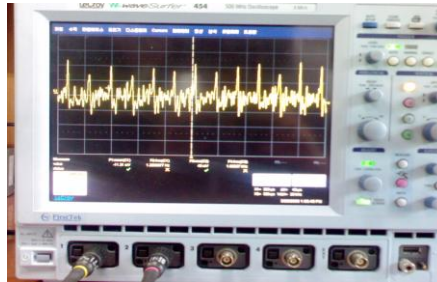


Figure 11. Measured waveform of pulse sensor

The data measuring the output voltage of the piezo sensor is shown in Table 2 and the number of samples were 10.

Table 2. Output voltage of Piezo film sensor

Piezo Film sensor sample number(DT2-028K)	Output[mV]
#1	98
#2	95
#3	96
#4	98
#5	93
#6	85
#7	88
#8	90
#9	95
#10	97

The measurement of the temperature sensor was obtained by installing the temperature sensor on the bottom of the mobile terminal and indicated temperature of the mobile terminal and the digital thermometer is shown in Table 3.

Table 3. Output voltage of Piezo film sensor

Portable device sample number	Measured temperature of portable device[°C]	Reference temperature [°C]
#1	31.5	31.49
#2	31.8	31.75
#3	32.0	32.12
#4	32.3	32.26
#5	31.6	31.55

For the configuration of wireless sensor nodes, as shown in Figure 12, the antenna was connected to the wireless sensor node undergoing an interworking test with the u-Healthcare sensor network base gateway.



Figure 12. Sensor node board

The gateway contains the ZigBee modem for the connection to the sensor module, ZigBee Module for the connection to the sensor node and the CF Type WLAN Card for the connection to the Access Point. Gateway internally connects to the UART and TTL for communication. The WLAN Card has a built in antenna for the connection with the Access Point and the WLAN Card Adapter has a built in Network IC for the IP selection. Accessing the server with the IP and receive the data from the ZigBee network and also transmits the data to the ZigBee network. For various tests it has a built in serial port for direct connection to the computer. Also when configuring a network each AP can configure a different network, and in this case, the ID value used to differentiate each network is SSID. In other words, when configuring a network infrastructure, by setting the SSID of the AP to whom you want to communicate with, it can enable the communication with the desired AP. For AP's SSID, refer to the AP instruction manual or it can be identified through the AP configuration program being used. If the SSID has not been set, it will connect to the first found AP during the power up. The maximum length of SSID is 32 bytes and the ASCII character can be used for the setting value.

Wireless LAN communication program is shown in Figure 13.

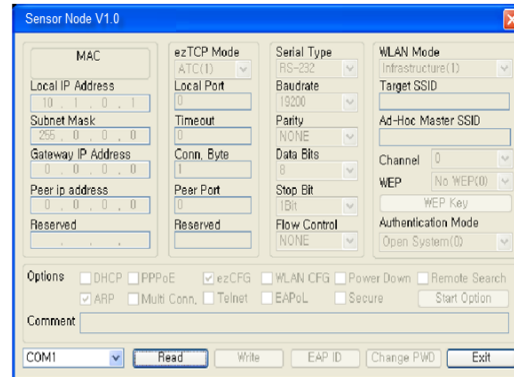


Figure 13. Program window of communication

4. Conclusion

The u-Healthcare, by using a variety of medical devices and sensors, monitors the condition of the patient remotely 'anytime, anywhere' and makes it possible to provide healthcare and medical services. Through this, the service can be provided to the parts of the region having difficulties for medical service and through real-time monitoring it is possible to cope with emergencies. Through the u-Healthcare system, for the healthcare of the elderly people living alone without proper health care services, it will become available to provide a variety of medical services. Also the realization of ubiquitous healthcare services will be practicable as the medical information system having emphasis on the interoperability between medical institutions or medical devices enabling frequent access and exchange of health information followed by the information security and privacy protection is expected to be a prerequisite factor for the vitalization of the convergence market such as the u-Health. Therefore in this study, the sensor module that can be used in the u-Healthcare system was designed and produced using configured information gathered from a variety of sensors through an inexpensive, easily configured wireless network ZigBee. A wireless sensor node and the gateway to process the sensor data occurring from each sensor was designed and produced. Through this, during an emergency for the patients and elderly people, patient's vital and location information can be applied to the important hospital system, and building a digital healthcare environment which is independent from time and place, ultimately could be able to implement the healthcare system of the ubiquitous era.

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