Design and Implementation of Ubiquitous Sensor Network System for Monitoring the Bio-information and Emergency of the Elderly in Silver Town

Seong Ho Choi, Hyung-Kun Park and Yun Seop Yu, *Member, KIMICS*

Abstract— **An ubiquitous sensor network (USN) system to monitor the bio information and the emergency of the elderly in the silver town is presented. The USN system consists of the sensor node platforms based on MCU of Atmage128L and RF Chip of CC2420 satisfying IEEE 802.15.4, which includes the bios sensor module such as the electrocardiogram (ECG) sensor and the temperature sensor. Additionally, when an emergency of the elderly is occurred in the silver town, the routing algorithm suitable to find and inform the location of the elderly is proposed, and the proposed routing algorithm is applied to the USN. To collect and manage the ECG data at the PC connected to the sink node, LabView software is used. The bio information and the emergency of the elderly can also be monitored at the client PC by TCP/IP networks in the USN system.**

Index Terms— **Ubiquitous sensor network, silver town, bio-information, emergency protocol, routing algorithm.**

I. INTRODUCTION

With the increase of the elderly population, that is, those aged 65 years and over, the public facilities fully equipping the necessities of food, clothing, shelter, culture, and healthcare are required, and the representative sample is the silver town [1]. Wireless health monitoring system using health sensors in silver town may assist residents and caregivers by providing non-invasive and invasive continuous health monitoring with minimum interaction of doctors and patients [2]. Therefore, ubiquitous wireless sensor network for the silver town environments may be needed. Generally, the silver towns have not been constructed any excellent infrastructure for sensor networks, and thus, optimum routing algorithm which create a routing path from the mobile sensor nodes with limited resource to a sink node is needed. Recently, we have proposed the power-, delay-, and emergency-efficient protocol for ubiquitous wireless sensor networks for silver town application [3]. Because the protocol has not applied really to a silver town yet, it is required to apply it to a real field.

In this paper, we will introduce the results to apply the proposed power- and delay-efficient routing algorithm and emergency-efficient protocol of ubiquitous wireless sensor network systems for silver town applications.

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II. WIRELESS SENSOR NETWORK SYSTEM

Fig. 1 shows the overall system architecture of ubiquitous wireless sensor network to monitor the bio information and the emergency of the elderly in the silver town, which consists of wireless sensor nodes, a sink node, fixed nodes, server PC, and client PC for remote monitoring. Wireless sensor network consists of a large number of small sensor nodes, which have built-in computing, power, sensors to acquire bio-information data from the human body and wireless transmission and reception capability.

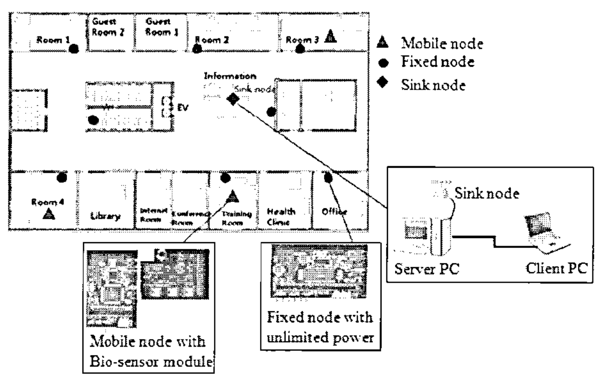


Fig. 1. System architecture of ubiquitous wireless sen sor network in a specific silver town

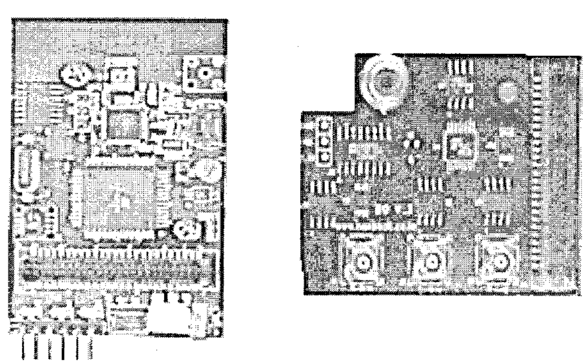


Fig. 2. Wireless sensor node and Bio sensor module

A. Wireless sensor network node platform

The wireless sensor nodes are responsible for acquiring the electrocardiogram (ECG) and body temperature data and transmitting it to the sink node. The sensor nodes have limited battery power, and computing, and communication capability due to the physical structure. As shown in Fig. 2, they consist of a low power Atmel128L 8-bit micro-controller, CC2420 wireless transceiver, and ECG and body temperature sensors [4]. Atmel128L incorporates various functions such as 128KB Flash, 4KB SDRAM, and analog-to-digital converter (ADC) function. CC2420 satisfies IEEE 802.15.4 by radio-frequency (RF) transceiver and use 2.4 GHz bandwidth that is ISM band, and achieve radio communication function that is safe at the low power due to selecting direct sequence spread spectrum (DSSS) mode. Sensor module includes the manufactured ECG and body temperature sensors [4].

B. Wireless sensor network in the silver town

Fig. 1 shows also a specific silver town to apply the proposed power- and delay-efficient routing algorithm and emergency-efficient protocol of ubiquitous wireless sensor network systems. One sink node monitors all sensor nodes. A fixed node (without any limited resources) is established at one point which can communicate with one-hop to both the sink node and the mobile sensor nodes in the dark region (in which mobile sensor nodes cannot communicate to the sink node). Their number and location are fitly fixed in the silver town such that they transmit the data from all mobile nodes in all dark regions to the sink node. The fixed nodes can be operated like the fixed cluster head. They can form a cluster, and can transmit the data collected from the cluster member nodes to the sink node. Power of all fixed nodes is supplied sufficiently to prevent the overload continued and the energy imbalance caused by the network to stop the destruction at the actual network environment so that their power is continuously supplied. All mobile sensor nodes except for the fixed nodes have limited batteries, and to recharge the batteries is impossible. Power-efficient protocol requires the energy conservation. All mobile sensor nodes have equal capabilities (in terms of data processing, wireless communication, and battery power). Links are symmetrical, i.e., two nodes can communicate using the same transmission power. All mobile sensor nodes have various transmission power levels, and each node can change the power level dynamically.

C. Software architecture

The software architecture for the ubiquitous wireless sensor network in the silver town was developed in TinyOS [5] which is an embedded operating system written in the nesC programming language as a set of cooperating tasks and processes. In TinyOS, the sensing data is transmitted with the data packet format. The transmitting and receiving packet between sensor nodes consists roughly of TOS message (for TinyOS message), data message, multi-hop message (for multi-hop routing). In this system, the data packet for transmitting the bio-information data of the elderly in the silver town is configured as Fig. 3. The overall packet consists of header data, multi-hop message data, data message, CRC, start bit, stop bit for 5 bytes, 8 bytes, 24 bytes, 2 bytes, 2 bytes, and 1 byte, respectively, and the total number of it is 42 bytes. For sync of the packet, both values of start and stop bit are always 0X7E.

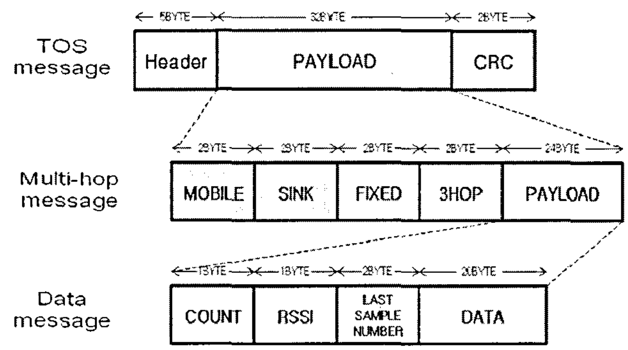


Fig. 3. Data packet format

D. Routing algorithm and emergency protocol

Firstly, the position and number of fixed cluster nodes in the silver town are determined as shown in Table 1 [3]. Secondly, the designer designs and establishes the routing path between the cluster head and the sink node. Thirdly, to form a cluster, a fixed cluster broadcast its node information to non-cluster heads (sensor nodes) [3]. If the fixed cluster head receives a joint message from a non-cluster head, it sends the TDMA schedule to the non-cluster head. Otherwise, the cluster head waits a join message.

TABLE I
FIXED CLUSTER HEAD SELECTION ALGORITHM

Step	Function
1	Arrange arbitrary the positions(X,Y) of the fixed cluster head.
2	Form the cluster. Fixed nodes broadcast the node information. Mobile nodes compare RSSI and LQI received from the fixed node. If the RSSI and LQI are larger than threshold, join to the cluster.
3	If sink node receives data of the all node, the number of fixed node is reduced. Then, repeat the steps 1 and 2.
4	We optimize the location and number of fixed nodes by repeating the step 3.

When an emergency situation at a mobile sensor node occurs in the silver town, the mobile sensor node broadcasts the emergency signals with maximum RF power to all the nodes. Emergency message is received to a fixed cluster head, and then the cluster head sends the Received Signal Strength Indicator (RSSI) of the emergency node to the sink node. The location of the emergency node can be estimated by the server connecting to the sink node with the 2 dimensional location awareness using RSSI mode [6], but in the proposed protocol, it is estimated roughly with the identification (ID) number of the fixed cluster head including the emergency node. Also, when an emergency situation at a mobile sensor node occurs in the silver town, the mobile sensor node broadcasts the emergency data packet to the fixed cluster head, but then the emergency data packet may be come into collision with the scheduled data packet at the cluster head. Therefore, to be delivered without any collision and delay to the cluster head under emergency situation, the new emergency protocol[3] is applied to the system.

D. Clustering period

The proposed routing algorithm can change network lifetime according to clustering period. As the clustering period increases, the network lifetime increases [2]. However, the clustering period could not be increased infinitely because mobile nodes change their cluster by waking or running of the elderly. Therefore, it is required to determine effectively the clustering period.

The simulated error rate of position due to periodically clustering is shown as Fig. 4. The error rate for location of the elderly is minimum in the case of the clustering period = 10 second. Because the mean velocity of the elderly is 2 ~ 3 km/hour and the mean area of a cluster is about 50 m^2, the clustering period can be set to about 10 second as the worst case. From Fig. 4, we can know that the error rate increases due to frequent clustering at clustering period of below 10 second and also increases due to escaping the cluster of the mobile node at clustering period of over 10 second. Therefore, this system sets the clustering period to 10 second.

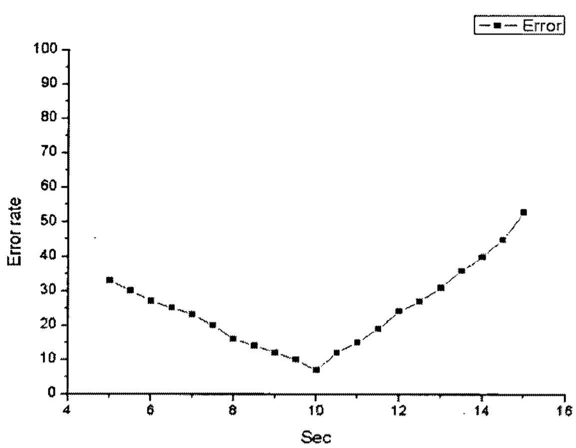


Fig. 4. Location error rate versus clustering formation time

III. SIMULATION AND EXPERIMENTAL RESULTS

We applied the proposed power- and delay-efficient routing algorithm and emergency-efficient protocol of ubiquitous wireless sensor network systems to the silver town environment as shown in Fig. 1.

Figure 5 shows the ECG signal tested with the monitoring program developed by LabView software [7]. The typical ECG signal of the elderly is shown. Figure 6 shows the ECG signal stored to the database (MS Access). Date, time, ID number of mobile node, existence of heart beat, and pulse count are stored.

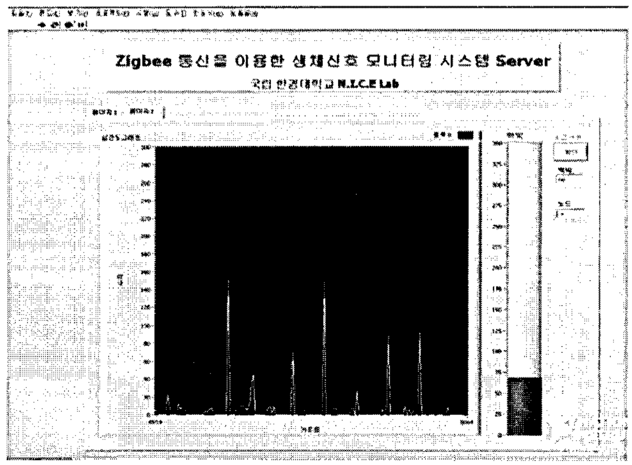
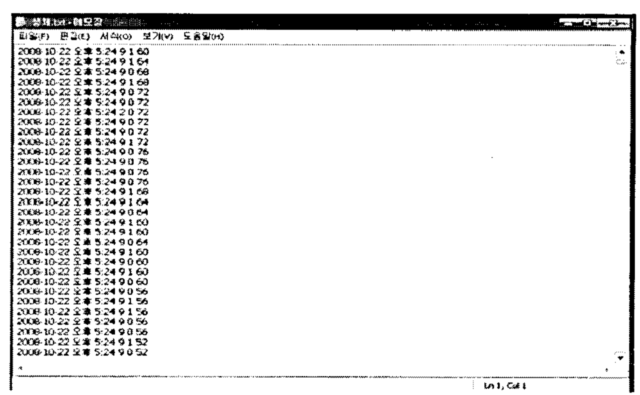


Fig. 5. Experiment screen showing ECG signal at server PC, developed by LabView software


파일(F) 편집(E) 서식(O) 보기(V) 도움말(H)
2008-10-22 오후 5:24 9 1 60
2008-10-22 오후 5:24 9 1 64
2008-10-22 오후 5:24 9 0 68
2008-10-22 오후 5:24 9 1 68
2008-10-22 오후 5:24 9 0 72
2008-10-22 오후 5:24 9 0 72
2008-10-22 오후 5:24 2 0 72
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2008-10-22 오후 5:24 9 1 52
2008-10-22 오후 5:24 9 0 52

Fig. 6. Experiment screen showing ECG signal database at server PC

Figure 7 shows the ECG signals of client PC transmitted from those of server PC with TCP/IP communication, developed by LabView software. The ECG signals of client PC are same to those of server PC.

Figure 8 shows the emergency monitoring indicating the location and ID of an elderly when the elderly is under emergency circumstance. The emergency information can help the elderly safe under emergency circumstance.

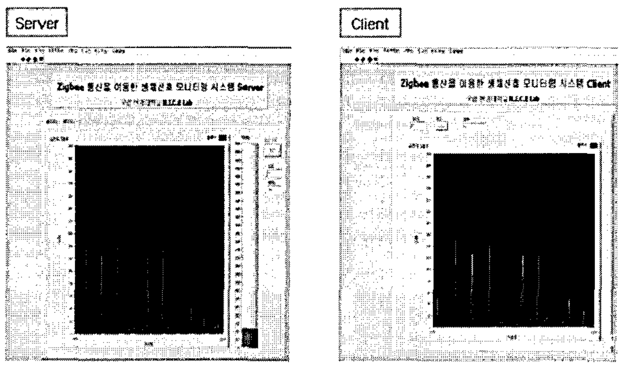

Fig. 7. Experiment screen showing ECG signal at server PC and client PC.

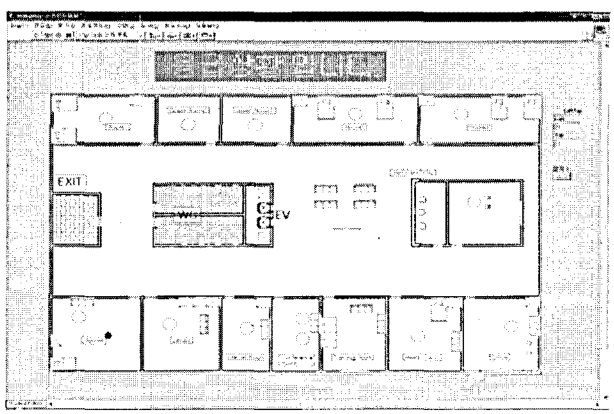

Fig. 8. Experiment screen in case of emergency monitoring

IV. CONCLUSIONS

The implementation of USN system to monitor the bio information and the emergency of the elderly in the silver town was presented. The USN system consisted of the sensor node platforms based on MCU of Atmage128L and RF Chip of CC2420 satisfying IEEE 802.15.4, which included the ECG sensor and the temperature sensor. Additionally, when an emergency of the elderly was occurred in the silver town, the routing algorithm suitable to find and inform the location of the elderly was proposed, and the proposed routing algorithm was applied to the USN. To collect and manage the ECG data at the PC connected to the sink node, LabView software was used. The bio information and the emergency of the elderly can also be monitored at the client PC by TCP/IP networks in the USN system.

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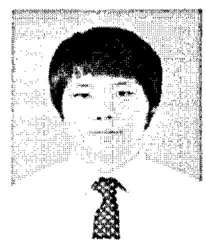

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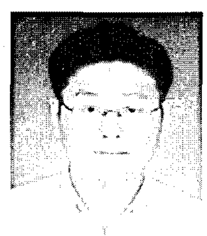

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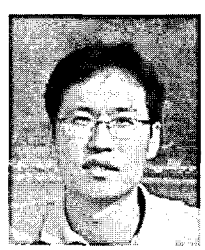

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