Development of Construction Site Safety Monitoring System based on the USN

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Abstract—This paper proposed the safety helmet monitoring system based on USN(Ubiquitous Sensor Networks) to secure the wear of helmet for labor on the construction area. As one of the most significant gear to assure labor's safety, The safety helmet would have the extend of labor's injuries minimized whether one wears or not when an accident takes place. At this point, we have developed and demonstrated the system which is able to check who wear the safety helmet properly for labors, composed of safety helmets with sensor node, router nodes, sink node and management program. Moreover, we could show optimized parameters for the proposed USN system as doing experiment and demonstration, we expected that this system would make for labor wear the safety helmet properly on the construction area as well as prevent economic injury caused by an accident with not wearing for labors.

Index Terms—USN, Safety Monitoring System

I. INTRODUCTION

Now, we is undergoing a rapid transition toward new era which is called Ubiquitous environment as IT development has been intelligent, informative, complicated[1]. In that manner, USN(Ubiquitous Sensor Network) referring to wireless networks consisting of sensor nodes having the ability to sense and process message and wirelessly communicate with other nodes, routers and a sink node is a good solution to come up with and has being focused as favorable business model. These sensor networks can be widely applied on all over industry and particularly used in the following applications such as health, military, asset tracking, blood management, bridge maintenance, inventory management as well as construction site. In case of construction site, the sensor network has already been used to manage labor resource and check the status of concrete and materials[2]-[6].

As statics of the Korea Occupational Safety & Health Agency (KOSHA), the rate of falling, cash and the related on a total accident in construct site is about 35~40%. Moreover, that rate is steady over past 5 years and when accidents take place, the labors might be wounded on head at a rate of 40%. As considering on these statics, we can say that the accidents of falling, crash, and the related take place frequently over years and many of injury people are wounded on their head. So, it is most important to wear safety helmet properly with other protection gears when accidents happen[7].

In matter of fact that safety helmet is most important, the accident rate specially for related with labor's head in a construction site is rising steadily because of both labor's unfavorite of safety helmet and untied chin strap.

The safety helmet prevents a labor from deadly being wound and dead as reducing a impact for labor's head by 90%.

In that point, we have proposed a novel USN application called the safety helmet monitoring system which could make labors wear the safety helmet properly with chin strap and manager keep track of the status of labor easily.

II. The proposed system schematic

Fig.1 shows the full picture of the proposed USN system. The proposed system is composed of 4 parts roughly: One is the sensor node attached with safety helmet sending messages to cabin which are capable of knowing for manager who wears the safety helmet.

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Two is router node expanding network coverage and relaying message packet of sensor node to sink node. Three is sink node to make all messages from sensor node together. Finally, four is management program and system to process the gathered message and supervise labor.

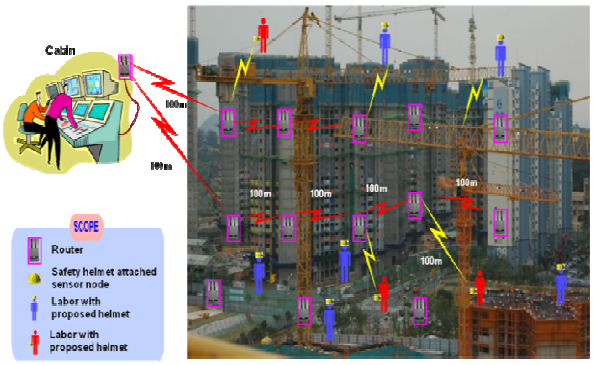

Fig. 1 The proposed system schematic

Router node should be installed on consideration of network coverage first and sink node and management program should be installed in order. If all system set up, the routing network is achieved upon programmed Operating System. And then all system is ready to start. After that, the proposed helmet will power up and broadcast messages 3~5times telling manager that the labor wear the safety helmet as soon as a labor wears it with chin strap properly. After that, sensor node sends a beacon continuously and periodically unless there are events. And it send messages 3~5times telling manager that the labor don't wear the safety helmet as soon as a labor take off the helmet or release the chin strap.

There is battery information on every messages to check it's life time. That's because all sensor node are battery powered terminals.

All of the messages get together by sink node and sink node send to connected management system on cabin and manager could supervise the labor's safety easily and efficiently.

III. System setup and configuration

Table.1 shows that hardware configuration of sensor, router and sink node on the proposed system. All node are consisted of MSP CPU of Ti corp. for low power system. We adapted different MSP chip for sensor node and router &sink node because a load of work is different. In case of RF chip, we adapted CC1070 UHF transmitter for sensor node because it only send a message without receiving any message. On the other hand we adapted CC1020 UHF transceiver for router and sink node because those should communicate each other to make routing network and relaying sensor node message to sink node. The output RF power of them is set to be 0dbm on consideration of battery life time and communication range. As you can see, we use UHF RF chip for communication. That's because we want to make our proposed system more robust and reliable in the hush RF communication environment such as construction site. The system using UHF band is more efficient than any other using 2.4Ghz or 800MHz band. So we could reduce the number of router in system and the installation cost.

Table 1 Hardware component and configuration

	Sensor node	Router &sink node
CPU	MSP430 F2322	MSP430 F1611
RF	CC1070	CC1020
Sensor	Magnetic Reed	N/A
LED	LED & LED switch	Power ind. LED
Power	Battery AAA x 2(3V)	Wired power(5V)
Serial	N/A	MAX-232
Frequency	424.825MHz transmitter	424.825MHz transceiver
modulation	GFSK	GFSK
Data rate	Up to 153.6kbps	Up to 153.6kbps
Distance (LOS)	Over 700m	Over 1.4km
LNA	N/A	Available
OS	Firmware	TinyOS
RF power	0 dBm	0 dBm

Magnetic Reed sensor from MK corp. is located on chin strap to check who wears the safety helmet.

MAX-232 chip for RS-232 is used to connect sink node with management system.

LED of sensor node turns on periodically and when it send a message. Led helps the labor make not only sense it's operation sensor node but also prevent him from accident as it blinks especially on night. And Led of router and sink node indicates their operation for manager.

We adapted LNA (Low Noise Amplifier) for amplifying incoming a message from sensor node in router and sink node. We don't have to worry about power for router and sink node as adapting LNA

because those are wire powered.

Like usage of UHF RF chip. That makes router receive more messages from more sensor node. And we could save the cost of installation. Fig.2 shows that the proposed safety helmet attached with sensor node and router, sink node.

Fig. 2 The pictures of safety helmet attached sensor node and router & sink node

Fig. 3 The management program of safety helmet monitoring system

Fig.3 shows the management program of safety helmet monitoring system. This system is concreted with Microsoft Visual C++ 6.0.

The management program also is composed of 4 parts roughly. One is the labor management menu which use when the data of labor is entered or modified the information of labor on the request of manager. The information of labor includes name, assigned work area, and theirs cellular phone number and given sensor node ID. Two is the list of all labor. You can see the entire list on the most left side of Fig.2. In this list, it show every labor's entire name and given ID, status of node and battery information. If the labor wears the safety helmet with chin strap properly, one is listed on the entire list of labors with blue sign. On the other hand, if labor doesn't wear the safety helmet or with chin strap untied, one is listed on the entire list of labor with red sign and additionally is sorted as labor who don't wear the safety helmet with red sign and name, ID, cellular phone number. You can see the list of labor not wearing the safety helmet on the middle of Fig.2. Being different from both wearing and not wearing the safety helmet, there are deflect list of labor sink node don't receive a message or beacon at given time as the labor run away out of construction site or being located on shadow area. In that case, one is listed with blue sign and labor's name, given ID, cellular phone number as the deflect labor as you can see the most right side of Fig.2.

IV. Transmission experimental result and discussion

The transmission protocol has been developed for our system. To meet less 0.5% PER (Packet Error Rate), the protocol is consist of more 24bit preamble and more 16bit sync word and user data and 2bytes CRC to check transmission error[8].

The sequence of sending messages for sensor node shows in Fig.4.

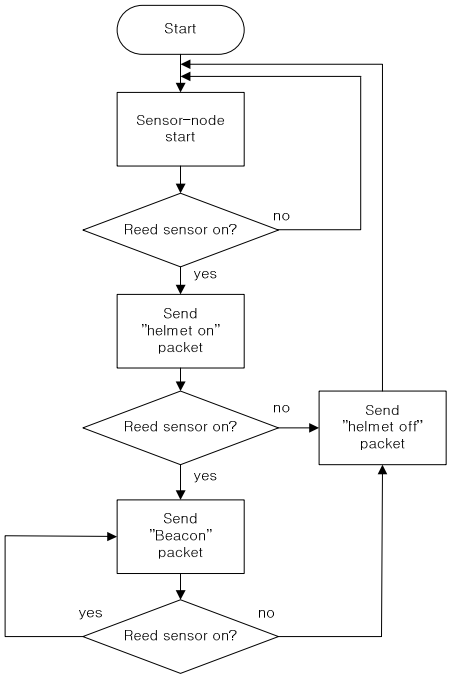

Fig. 4 The sequence of sending messages for sensor node

On open space, the transmission distance between router node and sink node is over 1.4km with LNA and between router node and sensor node is over 700m.

On construction site, the transmission distance between router node and sink node is over 4 floors and between router node and sensor node is over 2 floors with good transmission performance. Those experimental

results are outstanding compared with traditional zigbee system and considered as efficient system.

In our proposed system, the battery life time of sensor node is important factor to decide its efficiency and reliability. Battery life time of typical sensor is depends on the absence of active sensor, RF power, transmission protocol and so on[9].

On our proposed system, we are able to change configures of sensor node on the request of manager. To give a manager system flexibility and optimized configures, we have conducted battery life time simulation using C program.

Table 2 Simulation parameter

Battery capacity	1800 mA
Beacon Interval	30 sec
Beacon duration(Tx)	0.1 sec
Current consumption at beacon mode	18 mA
Led Interval	2 sec
Led duration	0.1 sec
Current consumption at LED on	3mA
board current consumption at idle	0.003 mA

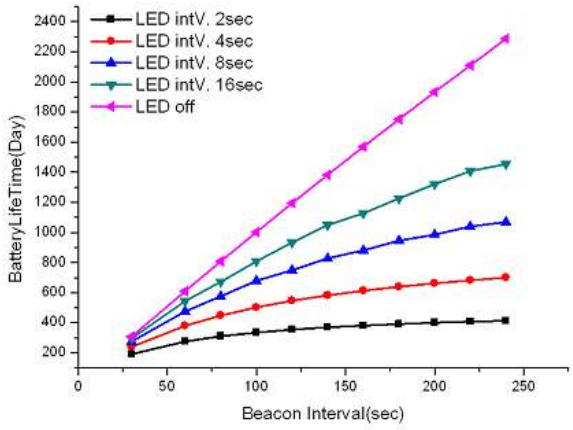

Fig. 5 Battery life time versus safety helmet LED and beacon interval

Table 2 shows one of the simulation parameter. And Fig. 5 represents the battery life time versus safety helmet LED and beacon interval.

We know that the longer beacon interval is, the longer battery life time we have and we use LED frequently, battery life time get shorten. We can also see that the rate of battery life time lengthen as setting beacon interval longer is depends on the usage of LED because LED current consumption is considerable. Of course, Brightness of LED is one of consideration, we lay aside that factor because we have set optimized brightness. As a conclusion, there is a trade-off between LED and beacon interval and battery life time.

As conducting this simulation, we make the our proposed system flexible parameter as an environment and on the request of manager.

V. CONCLUSIONS

We have proposed new application of USN system monitoring the safety helmet of labor in construction site. Being different from zigbee which is used widely, new system has developed for minimum size, low power consumption, simple structure, software as well as wide communication coverage using UHF band that makes the cost of installation reduce.

We have experimented transmission with some of sensor node, router node and sink node to verify its efficiency and performance. When this system is adapted and applied on construction site.

We expect that this system will assure labor's safety as wearing the safety helmet with chin strap properly and prevent the rising of construction cost from accidents and the related.

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