Wireless Nurse Call System

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Abstract: This paper develop a nurse call system using the wireless communication to resolve that a portable problem of established nurse call system. The established nurse call system has a problem that don't use outside of the sickroom because using a wire communication. The proposed nurse call system is composed of a terminal for nurse, a terminal for patient and a server part. The efficacy of the proposed system is verified by means of experimental. Experimental results are presented that show the effectiveness.

1. Introduction

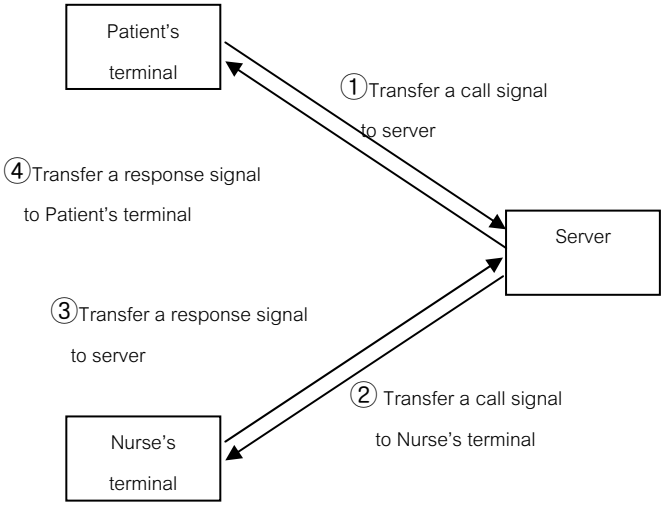
Recently, as the elders are increasing, medical facilities and social welfare-related industries will be increasing with the development of IT technologies.

For example, some products applying the technology of VoIP (Voice over Internet Protocol), and Wireless LAN have been lunched recently, and forward health-related application development based on IT new technology will be extending continually. [1] Nurse call system, which inform nurses a patient's emergency immediately so that they are able to take care the situation faster then before, is becoming an essential system in Silver Town, in particular, elderly care facilities, and large medical institutions. The existing nurse call system in domestic is wired nurse call system formed analog system and only calling bell system formed wireless system. Like those systems are installed in each sick room, so there are a lot of problems that patients are not able to call the nurse besides their rooms, and also the system is offering limited service because of analog methods and it is hard to be synthesized with computation system. [2]

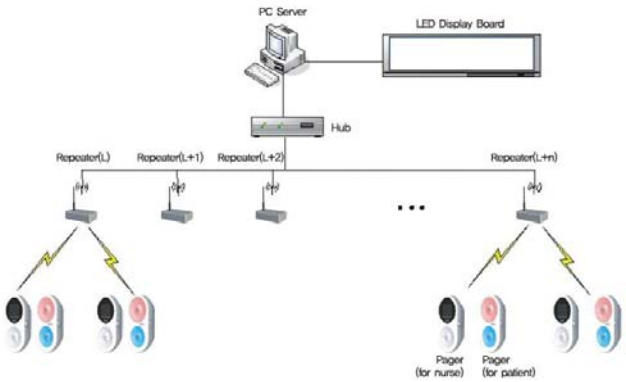
In order to improve the problems of the existing Nurse-Call system, we develop a wireless nurse call system. [3] The technique of developed system is combined by wireless communication, RFID, and Networking. The developed system is composed of a patient's terminal, a nurse's terminal, and a server. In order to verify the effectiveness of the developed system, we experiments on response time and success rate of each call.

2. Configuration of Nurse Call System

This wireless nurse call system has divided two parts of a terminal and a server generally. The terminals are a patient's terminal and a nurse's terminal using the wireless communication of 2.4 GHz band. The server part collects and processes the information from the terminals. Additionally, there are repeaters that transmit the data from the terminal to the server. Repeaters and terminals will perform wireless communication used by 2.4GHz band, and contact the server using TCP/IP. Figure 1 shows an overview of developed system behavior. The action sequences are shown in Figure 1 (a) and the like.



(a) Block Diagram



(b) Concept Diagram

Figure 1. Overview of developed system.

3. Terminal Part

Those terminals of wireless nurse call system are divided into a portable patient's terminal and a portable nurse's terminal. Each terminal uses 2.4GHz frequency band, and delivers the wireless signals to the server through the repeaters.

A chip used in each terminal uses 'CC2430' of Texas Instruments. 'CC2430' chip is a System chip, included 8051 core, Flash Memory, to be possible as a low-power RF Application. Table 1 shows the specification of 'CC2430'. [4] Terminals designed to optimize the size and expense.

Table 1 Specification of CC2430

Frequency	2.4GHz
SoC	CC2430
MCU	8051
Flash	32, 64, 128kByte
RAM	8kByte

When terminals communicate with other terminals or repeaters in 2.4 GHz RF band, and those put commands in each packet of certain location. In each case, each command is fixed, communication commands are listed in Table 2. Servers in the TCP / IP communications over the data sent in each case, the command line to convert the RF transmit packets. The server transfers data to repeater through TCP/IP, and then repeaters transfer RF packets.

Table 2 Communication Command

Command	Description
0x00	Normal Call Request
0x01	Emergency Call Request
0x02	Patient Call ACK
0x03	Normal Call ACK
0x04	Emergency Call ACK
0x05	Patient Call
0x06	Download ACK
0x07	Download Request
0xF0	Nurse Call ACK
0xF2	Patient Call
0xF3	Normal Call Request
0xF4	Emergency Call Request
0xF5	Patient Call ACK
0xF6	Download Data
0xF7	Terminal for Patient ACK
0xF8	Terminal for Nurse ACK
0xF9	Terminal for Nurse Fail ACK
0xE0	Emergency Call Signal

3. 1 Patient's Terminal

When terminals communicate with other terminals or repeaters in 2.4 GHz RF band, and those put commands in each packet of certain location. In each case, each command is fixed, communication commands are listed in Table 2. Servers in the TCP / IP communications over the data sent in each case, the command line to convert the RF transmit packets. The server transfers data to repeater through TCP/IP, and then repeaters transfer RF packets.

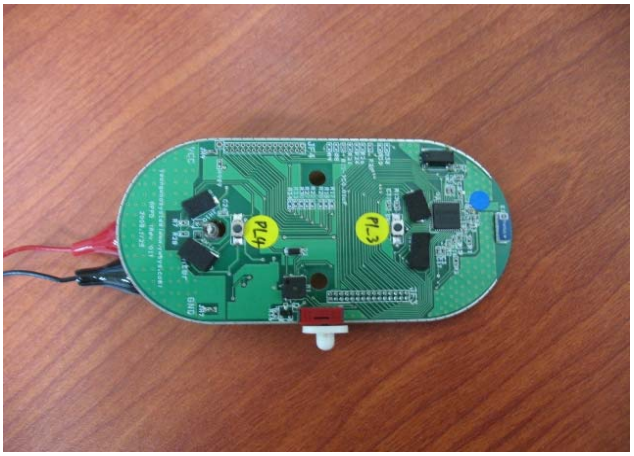


Figure 2. A circuit picture of the interior patient's terminal.

Figure 3. A picture of the exterior patient's terminal.

A call has two patterns, one is a general call and the other is an emergency call. As each calling button is pushed, if a nurse recognizes the call, the bell will be sounding.

In a general call, at the time that the general button is pushed, a stack of nurse's terminal is requested promptly. In emergency call, a patient has to push the button in three seconds cautiously so that all nurse include the stack of nurse's terminal are requested in ward. Also in this case, the bell will be sounding.

When a patient receives a nurse's call, some different sound is made. So the patient recognizes the nurse's call.

3. 2 Nurse's Terminal

Nurse's terminals are able to response to a patient's call, and also call a patient. Unlike the patient's terminals, the Nurse's terminals have a OLED display, so that make the

nurse who makes a call. The terminals have four control buttons of OLED display, and a calling button for a patient's response. Figure 4 is a circuit picture of the interior nurse's terminal, and Figure 5 is a picture of the exterior nurse's terminal

Nurses in charge should download the list of each patient from the server, and then save and manage the data.

As a nurse gets a request of a patient, a OLED display shows the patient's name and a number of a room. Emergency and general call is able to be distinguished by sound and a message. In a general call, the message is transferred to a stack of nurse's terminal. In emergency call, all nurses include the nurse of charge are requested, so they can take care of the emergency.

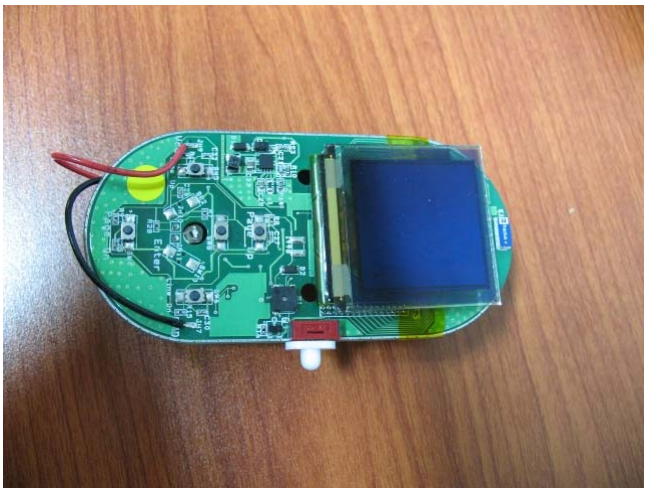


Figure 4. A circuit picture of the interior nurse's terminal.

Figure 5. A picture of the exterior nurse's terminal.

If a nurse needs to call a patient, the nurse will be able to choose the patient on the saved list through the OLED. In that time a patient's terminal response a nurse's terminal and a bell also will make sound by response.

4. Server Part

The server installed in Nurse-Center manages and process data of all patients. In addition, the serve responds request of each patient's terminal via Database; moreover, the server are managed of request by each terminal's serial number. For nurse's convenience, the server send the interface to nurses patients list.
The server receives data from terminals though repeaters that uses the TCP / IP.

4. 1 Call Behavior

As requesting a call from any terminal, the server searches which of terminals make a request by using a patient's number and a serial number based on Database. The server gives orders about where the terminal is to each repeater sequentially. If a repeater received the order is not able to find the terminal, next repeater will get the order and perform to find the terminal. A response signal will transfer to the requestor's terminal and finish the call behavior when the repeater finds the terminal.

Figure 6 shows a flow chart when a call is asked to a terminal.

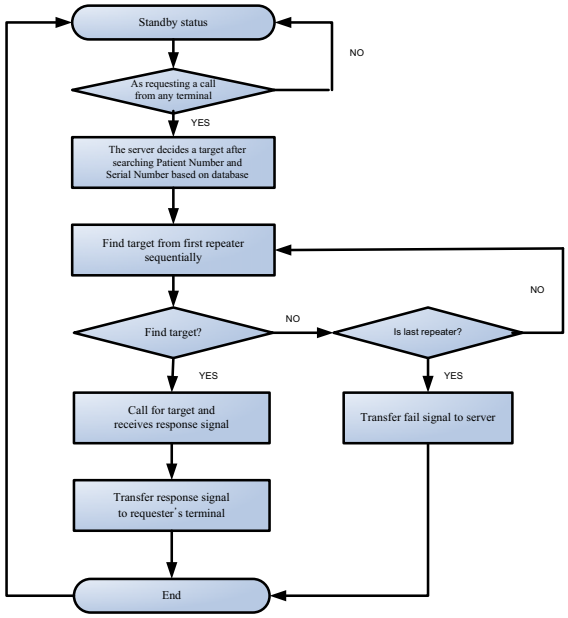


Figure 6. Flow Chart for Call Behavior.

4. 2 Download Behavior

As the nurse in charge is requested to download the list of patients, the server confirms the serial number of the terminal, and then the data is transferred to the terminal. The server is watching ACK of the terminal whether the list of patient downloads well or not. Figure 7 shows the flow chart of the download behavior.

The terminal is not able to do different behavior during the download behavior.

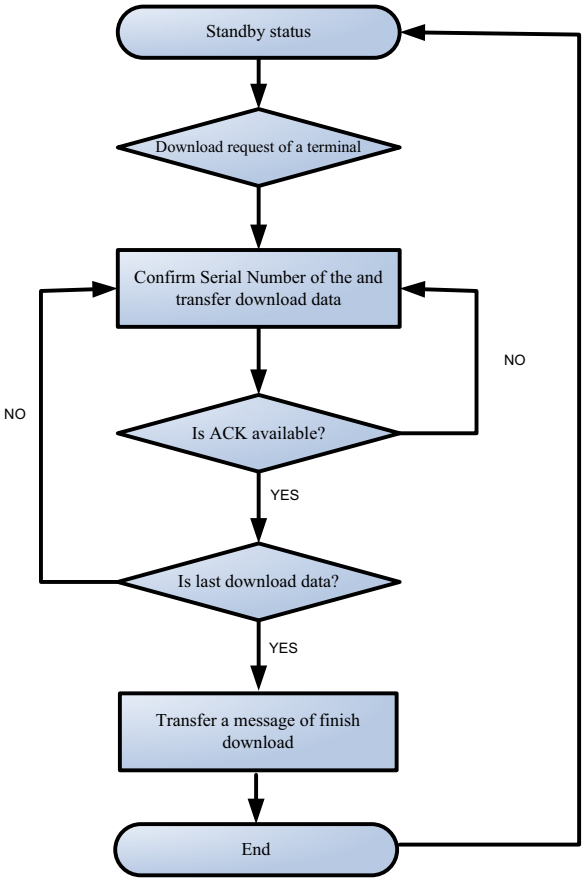


Figure 7. Flow Chart for Download Behavior.

5. Experiment

In order to verify the effectiveness of the developed system, we experiments on response time and success rate of each call. Experiment is performed indoors, which place was similar with real place.

Even if a possible maximum length of RF communication was 50m under the specification of the chip, we performed the experiment on 40m indoors. One repeater was installed, and the data measured every 10m. Table 3 is success rate of each call.

Table 3 Success Rate of each call

distance / terminal	10m	20m	30m	40m
Patient's terminal	100%	96%	91%	81%
Nurse's terminal	100%	95%	90%	80%

Success rate of each call was confirmed the different percentage by distance.

The response time was measured from beginning a call to receiving the response signal. Table 4 is a measure of response time by the distance.

Table 4 Response Time

distance / terminal	10m	20m	30m	40m
Patient's terminal	0.45sec	0.48sec	0.5sec	0.51sec
Nurse's terminal	0.46sec	0.49sec	0.5sec	0.52sec

Response time by the distance was somewhat different, but every time was within 0.5 sec.

This experiment performed only one repeater. In the real, there are enough repeaters in order to solve limited-distance problems.

6. Conclusions

In this research developed a wireless nurse call system in order to improve the problems of existing nurse call systems that patients are not able to call the nurse besides their rooms, and also the system is offering limited service because of analog methods and it is hard to be synthesized with computation system.

Developed system is composed of a patient's terminal, a nurse's terminal, and a server installed Nurse Center. Additionally, there are repeaters that operate to process the data from wireless communication, and transmit those data to the server. Repeaters and terminals will perform wireless communication used by 2.4GHz band, and contact the server using TCP/IP.

In order to verify the effectiveness of the developed system, we experimented on using one repeater. The results of response time and success rate of each call were summarized as follows:

- Response time of patient's terminal was 0.51 sec and nurse's terminal was 0.52 sec at 40m distance.
- Each call success rate of patient's terminal was 81% and nurse's terminal was 80% at 40m distance.

Future work will include location tracking system and various applications.

Acknowledgements

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