Wireless Body Area Network For Monitoring Body Temperature, Heart Beat And Oxygen In Blood

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Abstract—**Wireless body area network (WBAN) is a term used to describe a network of sensor devices connected wirelessly for communication on, in and near the body to obtain physiological data from sensor devices. This paper explain the implementation of WBAN for monitoring body temperature, heart beat rate and oxygen saturation in blood. We develop the sensor reads physiological data to the desktop application, then will read the printout of the series and create a visual in the tables and graphs, as well as storing the data into a database and displayed via a website in the form of reports that can be accessed remotely. We analyze the data received from sensor nodes to server receiver with a variety of different distances 10, 20, 30, 40, and 50 meters. The experiment results show that the physiological data can be accessed through ZigBee wirelessly in short distance which suitable for WBAN.**

Keywords—WBAN; e-health; body sensor, body temperature; heart beat; oxigen saturation

I. INTRODUCTION

Wireless body area network (WBAN) is a biomedical sensor network nodes connected wirelessly to the communication on, in and near the area of the body, which monitoring the real data of body to improve health care [1,2,5,6]. The network is composed of nodes biomedical small and low-power. Body area network (BAN) is communication between humans and computer through wearable devices. The features of wearable devices are body worn computer, which always on, ready, and accessible [1]. These devices provide health care monitong and feedback to the user or medical personnel. The information of health can be recorded over a longer period of time to improve the measurement quality of data.

WBAN architecture is consists of three layers which act sensing, processing, and transmitting. sensor nodes are in the position of the lowest layer. Their capability are monitor the vital signs and critical data of human body in different locations. The second layer is personal server such as smart phone, persoal computer (PC), etc, that can connect to internet. The third layer is remote server which receive transfered data from personal server. The communication of intra BAN may use wireless, i.e. Zigbee and bluetooth, or wired, or mix of wireless and wired. While the communication of extra BAN is wireless over WiFi, GPRS, etc.

A number of researches have been conducted on implementation of WBAN application. Mehmet et al. [3] implemented multi-hop topology network for a WBAN system that can be used to remote monitoring of physiological signal parameters. The authors user medical bands medical implant communication service (MICS) for short range communication in intra BAN and wireless medical telemetry service (WMTS) for long range communication in extra BAN.

Sim et al. [4] implemented two kinds of noninvasive thermometers to calculate the deep body temperature in bed nonintrusively by simulation. This system is supposed to decrease heavy nursing task by automatically monitoring deep body temperature of patients in hospital beds. The stored temperature data can provide useful health information such as sleep structure analysis. Keerthika et al. [7] implemented sensor circuit for detecting Oxygen saturation value of a person by using Pulse Oximeter sensor and interfaced with Microcontroller (PIC 18f4520). The liquid crystal display (LCD) will show the obtained value. The Oxygen saturation Saturated value is sent to the server monitorng by using GSM module. Alert is given to medical personnel for an immediate heatl care according to threshold valie in emergency.

Balasubramanian et al. [8] formulated the critical time parameters to evaluate the body area wireless sensor networks (BAWSN) operations such as the packet arrival, the error in the arriving packet, and the loss of packets. Healthcare Monitoring Application (HMA) has strict timing requirements concerning the arrival of data from the sensor nodes within the defined critical time. Clarke et al. [9] investigated the failure modes of the standard SpO2 measurement algorithm in the presence of motion artifact on the raw photoplethysmographs (PPG) signals.The authors use a Texas Instruments AFE4400 evaluation module to collect data. The experiment results showed a decrease in calculated SpO2 when the subject was moving versus at rest.

In order to implement wireless body area network system, the contribution of this paper is implement the body temperature sensor, heart beat and oxygen in blood sensor using e-health sensor shield V2.0 for arduino. The information from body monitoring is gathered wirelessly using ZigBee to server monitoring. We use ZigBee because it suitable for short range and low power consumption personal area network. We develop real time visualization monitoring application in desktop-based and web-based to get sensitive data in order to

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be analysed for future medical diagnosis. We implement health care system with single-hop topology. Then we construct different range between body sensor device and the body control device as gateway in term of the number of received data at server monitoring.

II. THE SYSTEM DESIGN OF WBAN

A. System Architecture of WBAN

Currently we are developing wireless body area network that is based on body temperature sensor and pulseoximeter sensor. We are also working to interface the devices with IEEE 802.15.4 ZigBee to cover body area network. The WBAN prototype system presented in this paper uses multi-hop topology where body control unit as gateway is used for gathered data from sensor devices as shown in figure 1. Each patient uses a sensor network in their body. The system comprises of body sensor unit (BSU), body central unit (BCU), and desktop monitor server. BSU communicates to BCU, which communicates the data of patient to remote desktop monitor server. BSU consist of arduino, e-health sensor board, arduino Xbee shield, ZigBee, temperature sensor, and pulseoximeter sensor; while BCU consist of arduino, arduino Xbee shield, and ZigBee.

Start from sensor readings in a sensor by using BSU, the information data will transmit to BCU wirelessly using ZigBee, then the data will be stored in the variable on the PC and stored into a MySQL database. The results from the database can be viewed via desktop-base monitoring application and the website-based in the form of a report. The data from the sensors is sent wirelessly using Zigbee and subsequently accepted by the receiver node which has been connected to a PC desktop monitor that will display the results received by the receiver into the program. The distance between sender and receiver changed from 10 meters, 20 meters, 30 meters, 40 meters and 50 meters.

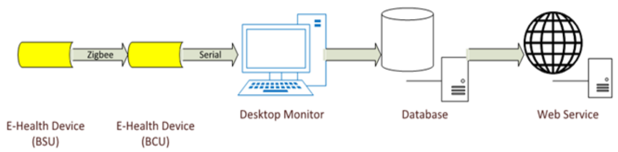

Figure 1. System Architecture of WBAN

B. Component of WBAN

The specifications of the hardware and software used in this paper are as follow:

a. Hardware (Hardware)
- Compaq Presario CQ40
- CPU: 2:40 GHz (Dual Core)
- Memory: 2048MB RAM
- Arduino
- E-health sensor

b. Software (Software)
- Windows 8 Professional 64bit
- Visual Studio Premium 2012
- Arduino IDE

Figure 2 shows the installation of temperature sensor and pulseoximeter sensor to e-health sensor board and paired to arduino uno as micro controller. The component contains server monitoring, body control unit (BCU), and body sensor unit (BSU).

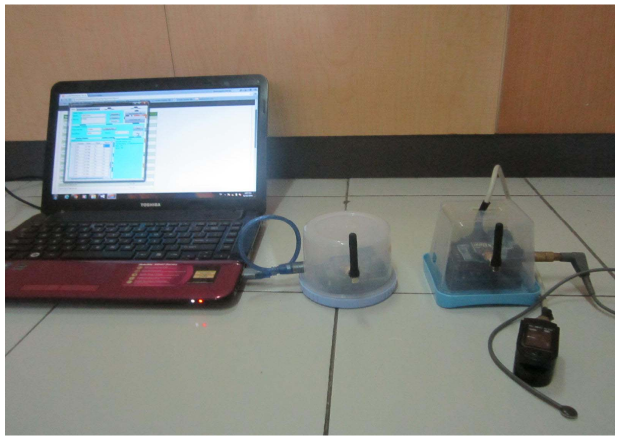

Figure 2. Server Monitoring, Body Control Unit, Body Sensor Unit

C. Visualization Design

Figure 3 shows the visualization design of the application. This application has several features among which can store user data, check the connection to the database, view the results in a database record, and perform serial monitor readings. The functions of each button in this application are added button: this button is used to add a new user into the application; clear button: it acts to remove the user; save button: this button is disabled because the function keys to perform user data storage. This button will be enabled when the add button is pressed; combo box port e-health: this combo box is used to determine which ports will be processed to be read; combo box baud rate: baud rate function to determine the port that will be read. This baud rate must be the same as that set on the Arduino; combo box device: function to determine which device will be reading the series; start button: function to open a port that has been set on the combo box port e-health as well as the appropriate baud rate to that of the e-health; stop button: working to stop reading the series; record table result: show the results of a table to store temporary data that has been read; results readings are legible on the serial output; and tab graphs: show the temperature charts and pulseoximeter result into a graph.

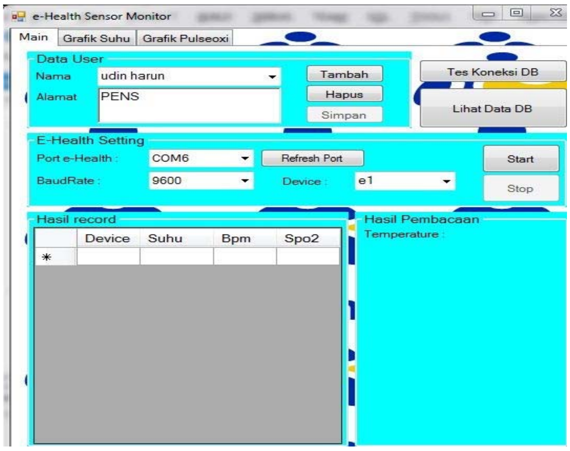

Figure 3. Desktop-Based Visualization Design

III. PERFORMANCE EVALUATION

In the performance evaluation phase, we implemented a single node single hop topology, where a BSU device acts as a sender and BCU acts as a receiver as shown in figure 4. During the testing, the distance between the sender and the receiver is changed from 10 meters, 20 meters, 30 meters, 40 meters and 50 meters.

Figure 4. Distance Between E-health Sender Device and Receiver Device

Figure 5 is the result of the sensor readings are done by the sender of device, and Figure 6 is the result of the image received by the receiver. We can see that the entry has been as exact as sent by the sender. These results have been marked by me in parts contained in the yellow box.

```
e1|39.77|87|98|z
e1|40.06|87|98|z
e1|39.83|87|98|z
e1|40.20|86|98|z
e1|40.00|83|98|z
e1|39.83|80|98|z
e1|40.23|82|98|z
e1|40.00|82|98|z
e1|40.16|78|98|z
e1|40.13|78|98|z
e1|40.06|79|98|z
e1|40.26|83|97|z
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Figure 5. Serial Monitor Sent by Sender Device

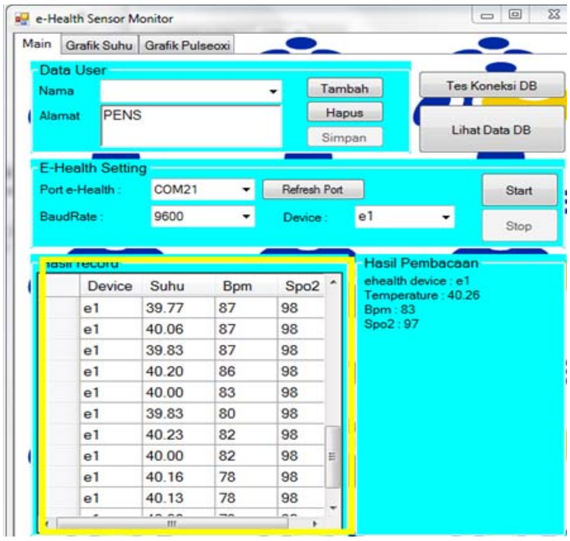

Figure 6. Data Received By Server Monitoring

Figure 7 shows the result of data that have been recorded into the database. The similarities of the data are also visible in yellow marked where the data are the same data that were sent by the sender and received by the receiver.

id_data	id_user	tgl_data	suhu_data	bpm_data	spo_data
780	8	2014-07-19 14:24:10	39.41	96	99
781	8	2014-07-19 14:24:15	39.38	95	99
782	8	2014-07-19 14:24:20	39.54	90	99
783	8	2014-07-19 14:24:25	39.8	93	98
784	8	2014-07-19 14:24:30	39.41	90	98
785	8	2014-07-19 14:24:35	39.73	93	98
786	8	2014-07-19 14:24:40	39.77	97	98
787	8	2014-07-19 14:24:45	39.8	90	98
788	8	2014-07-19 14:24:50	39.96	90	98
789	8	2014-07-19 14:24:56	39.93	88	98
790	8	2014-07-19 14:25:01	40	92	98
791	8	2014-07-19 14:25:06	39.8	89	98
792	8	2014-07-19 14:25:11	39.77	87	98
793	8	2014-07-19 14:25:16	40.06	87	98
794	8	2014-07-19 14:25:21	39.83	87	98
795	8	2014-07-19 14:25:26	40.2	86	98
796	8	2014-07-19 14:25:31	40	83	98
797	8	2014-07-19 14:25:37	39.83	80	98
798	8	2014-07-19 14:25:42	40.23	82	98
799	8	2014-07-19 14:25:47	40	82	98
800	8	2014-07-19 14:25:52	40.16	78	98
801	8	2014-07-19 14:25:57	40.13	78	98
802	8	2014-07-19 14:26:02	40.06	79	98
803	8	2014-07-19 14:26:07	40.26	83	97

Figure 7. Database Record

Furthermore, we put a red box as the delay that occurs in the database. From the time that the data shown in the red box marks the time differences which should be 5 seconds become 6 seconds. These differences can occur due to the process of data selection is done on the desktop application. Data from figure 5, which received at the receiver, must first split, thus it can be incorporated into the program and displayed.

After we conducted tests on a distance of 10 meters between the sender and the receiver, we tested again with a variety of different distances - the difference is 20 meters, 30 meters, 40 meters and 50 meters. The test is done in the same time 2 minutes at each distance. Since the time of delivery of the data packet has been set every 5 seconds, then in 2 minutes maximum data packet is sent as many as 24 packets of data. After 5 trials, we obtained the data as shown in table I.

TABLE I. RESULT TABLE

	10 meter	20 meter	30 meter	40 meter	50 meter
1st trial	24 packet data	24 packet data	24 packet data	16 packet data	14 packet data
2nd trial	24 packet data	23 packet data	18 packet data	24 packet data	9 packet data
3th trial	24 packet data	24 packet data	22 packet data	24 packet data	11 packet data
4th trial	24 packet data	24 packet data	20 packet data	18 packet data	14 packet data
5th trial	24 packet data	23 packet data	24 packet data	20 packet data	13 packet data
Average	24 packet data	24 packet data	22 packet data	20 packet data	12 packet data

The results obtained from trials at the same time that is 2 minutes, the distance changes, and conducted further experiments as much as 5 times the success in average data. Figure 8 shows a graph of the average number of received packet.

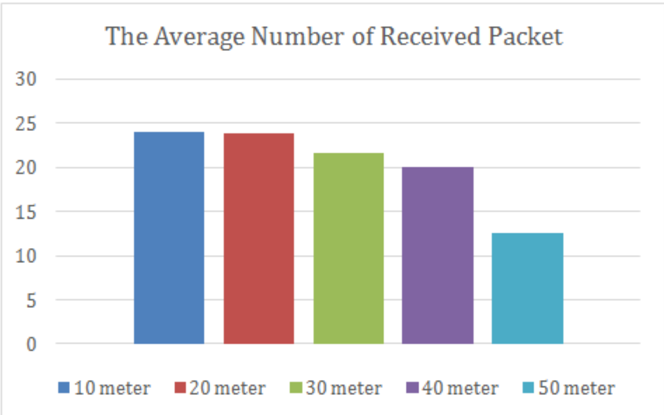

Figure 8. Distance vs. the Average Number of Received Packet

From the above result, we can see that there are sometimes losses of data packets that are not received by the receiver. The packets were lost because if the package is delayed, then the data packet will be able to appear in among other data packets. However, the data packets are not also out in among other data packets. Incoming data packets are not lost and cannot be received well and not automatically stored into the database. This is influenced by the greater the distance between the sender and the receiver, the incoming data packet the less successful. Due to the strong decrease of the signal between the sender and the receiver where the maximum communication distance of ZigBee short enough that between 10-70 meters. Thus, allowing data packets sent by the sender to the receiver does not get to the destination and cannot be received well. From this experiment, we should implement multi-hop topology for range that is more than 70 meter.

IV. CONCLUSION

This paper explains the implementation of body temperature sensor, pulseoximeter sensor including oxygen saturation in blood, and heart beat sensor. We analyze the data received from sensor nodes to server receiver with a variety of different distances 10, 20, 30, 40, and 50 meter. The experiments and analysis results show that the greater the distance, the more losses data received in server monitor due to decrease of the signal between the sender and the receiver. For further research, we have a plan to changing the way data transfer not only performed by zigbee, but can use other connections such as wifi and gprs to expand greater physical mobility of patient.

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