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RFID-Microcontroller based Wireless Medical Record

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***Abstract-* Patient care in hospitals is very important considered by the hospital to cure the patient. It can be an alarm and medical record. In the patient's room, we often encounter an alarm button that serves as an emergency button if the patient needs help immediately. The existence of which is usually placed on the bed of the patient is seen as less effective and difficult to reach if the patient were alone in the room and do not have enough mobility to press the button. In addition to alarms, patient care is also needed in the case of medical records (medical records). Write the patient's medical records manually are less effective and require more paper. In this paper, an alarm and medical record system are designed to implement patient care. By using wristband Radio Frequency Identification (RFID) tag installed in the patient's wrist, they can only raise and hold it to RFID reader, and then the data will be sent to nurse's room wirelessly. RFID is also used to access medical record website so that the data is more secure. The quality of service (QoS) parameters data in various distance are measured. It is shown that the designed system works well.**

Keywords— RFID Tag, RFID reader, microcontroller, medical record, wireless

I. INTRODUCTION

Application of computer and telecommunication technologies in various fields of life plays an important role because it could pass the boundaries of space and time and support the processes within an enterprise, especially in certain institutions such as hospitals [1].

RFID applications in hospital are relatively new if it is compared with the manufacturing sector, retail, library, logistic and supply chain. Many academics and practitioners believe that RFID technology has great potential to provide benefits for hospital. Based on [2], who conducted a study on how the application of RFID technology in a hospital in Taiwan, this study showed the reduction of operating cost, improvement the patient safety and quality of medical services. They also explored the benefits of RFID technology adoption and concluded that the use of RFID can improve medical services and patient safety. The author believe that some impact will be felt in Indonesia if RFID technology is applied in Indonesian hospital.

In Indonesia, the adoption of RFID technology in hospital is almost not available. Therefore in this research the author intends to introduce the use of these technologies to be applied in hospitals. RFID in this research is used as an identification tool for hospital staff and patient. With these RFID, the patient is able to access alarm and medical record and then the data of patient will be sent to web server with a wireless access point.

RFID as an alarm replace alarm button which we often encounter in patient's room because the button is seen as less effective and difficult to reach, with RFID tag installed in the patient's wrist, they can only raise and hold it to RFID reader and then data will be sent wirelessly. RFID is also used for accessing medical record to decrease using of many papers. Medical record will be accessed through a website with RFID as security entry.

The performance of used wireless network, i.e. Wireless LAN, can be measured by testing it to obtain the QoS parameters such as delay, throughput, jitter, and packet loss.

The specification of hardware and software that we used are Arduino Uno with ATMega328 microcontroller module, RDM6300 RFID reader with maximum reading distance 5 cm, EM4001 RFID tag with 125 kHz operational frequency. This card or tag is assumed can be in another form such as sticker placed on the patient's wrist. The programming language used is C for Arduino. Serial data from Arduino Uno module is inserted into a MySQL database with Python program. It is assumed that in the patient's room, there is a PC that has been integrated with the wireless adapter and an RFID reader and tag on patient. The server is used to register the patient for the first time they enter the hospital.This system can be implemented in the patient's room with maximum 2 members in that room, in this case VIP class and I class. QoS parameters tested are delay, throughput and packet loss.

The goal is to implement the Arduino Uno microcontroller and RFID in accessing the medical record of the patient. The database is built by the MySQL and presented in a simple website whereas the communication is using Wireless LAN (WLAN).

II. LITERATURE REVIEW

Some components applied to this research such as medical record, RFID tag and reader, Arduino Uno microcontroller, WLAN are described as follows.

Problem-Oriented Medical Record is a medical record which aimed to standardize data collection and analysis of medical data. It also supports the dynamic data development and can be easily assessed with immediate. The recorded data has to be filtered so that medical records can be arranged relatively short but complete [3].

RFID is a data capture technology that utilizes radio frequencies and can be used to electronically identify, track and store the information in RFID tags [4].

The main part of RFID tag is a microchip. When the tag is in the RF range generated by the reader, the tag will have enough power to access its internal memory and then transmit the information from the memory to reader [5].

Figure 1. EM4100 RFID *tag*

Because RFID systems require a reader that can read tags properly and communicates the result to a database, a reader is used.

Figure 2. RDM6300 RFID reader

The Arduino Uno is a microcontroller board based on the ATMega328. It has 14 digital input/output pins (of which 6 can be used as PWM output), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button [6].

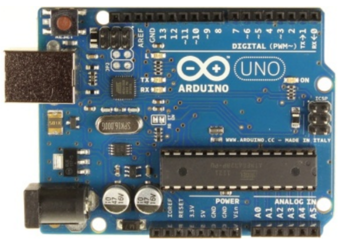

Figure 3. Arduino Uno module

Wireless LAN uses electromagnetic waves (radio and infrared) to communicate data and transmit it from one point to another point without going through the physical facilities. This connection uses a specific frequency to transmit the data. Wireless LAN mostly uses the 2.4 GHz frequency. This frequency called the Industrial, Scientific and Medical Band or ISM Band [7].

Packet loss is the percentage of lost packet sent to the receiver. IP networks are highly heterogeneous network. The information that will be sent is tended to change permanently caused by network error fluctuations [8].

Delay is the time to take the packet to be transmitted from one point to another point.

Throughput is the transmission speed average of a number of information per unit of time.

Jitter is the variation in delay that occurs as the result of a time lapse or interval between received packets. The amount of jitter is affected by the amount of packet collisions on the network internet protocol.

III. System Design

Design of system including hardware and software are explained below

Figure 4. System diagram block

In the figure 4, it can be seen that the main parts of the alarm system and medical records are the nurse's station and patient room. Nurse's station server provides the connection to the wireless LAN so that the patient's room which is in its range can access the internet. On the server there are a RFID reader, Arduino Uno and some RFID tags. In addition, there is database system to input the data of patient and process it.

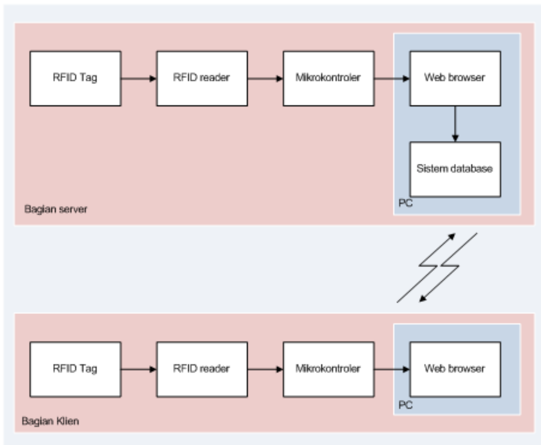

Figure 5. Diagram block of alarm system and medical records.

To access the alarm or medical records, the patient only need to get the tag closer to RFID reader. Serial output of the reader will be read and sent by the microcontroller to the PC via a USB to serial cable. The nurse will enter the server's IP address in the browser on PC of the patient's room.

RFID reader with Altium PCB is designed for RDM6300 reader so that it can be connected to Arduino Uno without using a project board.

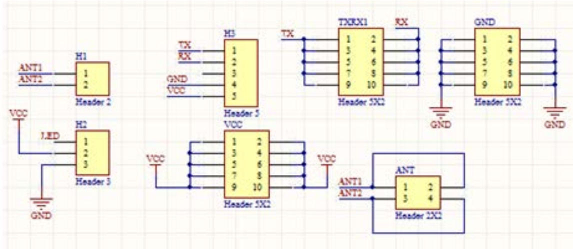

Figure 6. RDM6300 Board

RDM6300 module is connected to Arduino Uno so that the serial output of the reader can be read by the computer. TX pin from the reader is connected to a digital pin of Arduino. RX pin is not used because the reader is only used to receive input from the tag.

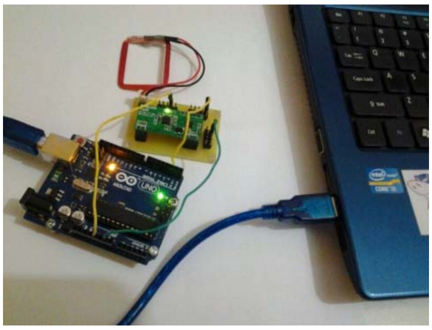

Figure 7. Arduino and RFID are connected to the laptop

Computer interface to an access point is required for accessing a computer networks wirelessly. In this research an access point TEW-430APB is placed between the server and the client computer. The wireless networks topology is a star topology which needs an access point so that each computer can connect to the internet.

Designing a database with MySQL is done to create the database of patients and access to medical records while they are in the hospital until they discharge. This database is filled by nurses at the server and the patient's room. The patients can only access some of determined data. Designed database for medical records is named medical_record consisting of multiple tables including serial_ip, data_kamar_pasien, data_dasar_pasien, data_login, laporan_pasien, and diagnosa_pasien.

The design of display includes making the website display with HTML and PHP. This display will be a graphical user interface between patients and the system.

RFID tag reading program is needed to read the serial output of a RFID reader RDM6300 when it held with a tag.

The program is written in C that compiled with the Arduino IDE 1.0.5 and the output can be seen in the serial monitor. Arduino board installed in the port COM36 has baud rate 9600.

In addition, the service program to input RFID data read to the database of MySQL is required.

IV. Testing and Analysis

4.1 Testing of RFID tag reading without obstacle

The test is performed to determine the distance between the RFID reader and the tags on the line of sight condition, without obstacles at the distance of 1 cm until 10 cm.

Table 4.1 RFID tag reading without obstacle

Numb.	RFID *tag* ID	Distances of reading (cm)	Obstacle	Result
1	6E00021473	10	No	Can not read
2	6E00021473	9	No	Can not read
3	4B00AA0320	8	No	Can not read
4	4B00AA031E	7	No	Can not read
5	4C00F31FF0	6	No	Can not read
6	4D00074A18	5	No	Read
7	4C00F31FF0	4	No	Read
8	4C00F31FF0	3	No	Read
9	4C00F31FF0	2	No	Read
10	4C00F31FF0	1	No	Read

According to the table 4.1, it can be seen that the RFID tag can be read at the distance of 5 cm without obstacle. It is meet with RFID RDM6300 datasheet.

4.2 Testing RFID tag reading with obstacle

On implementation in hospital, there will be possibilities when the tag cannot be read by reader. In this testing, we can know the tag and reader performance related above problem.

Table 4.2 RFID tag reading with obstacle

No.	RFID *tag* ID	Distances of reading (cm)	Obstacle	Result
1	4D00074A18	6	4 books	Can not read
2	4C00F31FF0	5	3 books	Read
3	4D00074A18	4	plastic	Read
4	4D00074A18	3,5	box	Read
5	4D00074A18	3	cloth	Read
6	4D00074A18	2	1 book	Read
7	4D00074A18	1,5	plywood	Read
8	4B00AA031F	1	book	Read
9	4B00AA031F	1	aluminum	Can not read
10	4B00AA031F	1	iron	Can not read

According to the table 4.2 it can be seen although between the tag and the reader was given obstacle, RFID reader can still read the ID tags at a distance of 5 cm. If the tag's location or the obstacle thickness greater than 5 cm, tags will not be read. If the obstacle is made of iron, aluminum or other metal materials, ID tags will not be read even in the distance less than 5 cm.

4.3 QoS (*Quality of Service*) Testing

In this test, a PC is used as a server and two laptops are as clients.

This PC has a wireless adapter so it can receive a wireless signal. PC is assumed to be in the nurse's office and the laptop is a hosted in patient rooms.

Table 4.3 Configuration of IP server and client

PC status	IP
Server (officer's room)	192.168.1.51
User 1 (patient's room 1)	192.168.1.52
User 2 (patient's room 2)	192.168.1.54

4.3.1 Testing at 6 cm without obstacle

This test is started by opening a browser and typing the server address. Then the log-in page will appear in the browser. Before clicking the address, run the Wireshark so that all of network activities will be captured by the software.

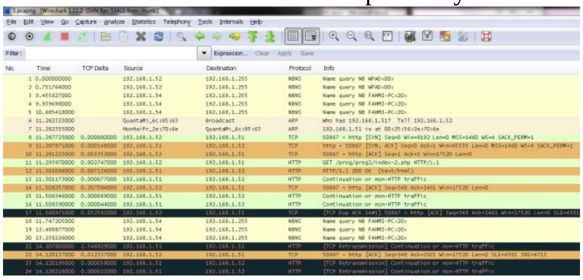

Figure 8 Result of Wireshark capture

There are so many network activities captured so it need filter to filter needed network data, such as round trip time of transmitter to receiver. *Filter* : (ip.addr=192.168.1.52 && ip.addr=192.168.1.51) && tcp.analysis.ack_rtt.

From this network data, we get result of network parameters such as delay, throughput, jitter and packet loss.

Table 4.4 Delay testing at the distance of 6 cm

Measurements	*Delay* (ms)
1	86
2	81,3113
3	35,359
4	61,027
5	53,86

In this test, the obtained delay is at 63,51146 ms, throughput is 3020,6698 bytes/sec, the jitter is 79,28 ms, and the obtained packet loss is 0 %. This result is in good category according to TIPHON version.

4.3.2 Testing at the distance of 15 m, 25 m and 30 m with two users

For testing at distance of 15, 25 and 30 m with one user are figured in table 4.5 and 4.6.

Table 4.5 Delay testing with one user

Pengujian ke-	*Delay* (ms)		
	15 m	25 m	30 m
1	61,9	49,33	84,02
2	51	23,38	64,32
3	59,9	51,8	70,41
4	50,5	45,79	66,5
5	61,9	53,9	67,3
Total	285,2	224,2	352,55
Rata - rata	57,04	44,84	70,51

Table 4.6 Throughput testing with two user

Pengujian ke-	*Throughput (bytes/sec)*		
	Jarak 15 m	Jarak 25 m	Jarak 30 m
1	2292,323	3592,409	4803,075
2	2853,484	3073,317	2290,241
3	2431,025	3901,651	8024,036
4	3014,736	4075,014	3854,217
5	2356,633	3487,845	2594,364
Jumlah	12948,201	18130,236	21565,93
Rata - rata	2589,6402	3626,0472	4313,187

According to the table 4.6 it can be seen that the farther the distance of observation, greater throughput that measured. If it is compared with the delay at the same distance in table 4.5, the ratio of them can be seen on the graph at the figure 4.2 below.

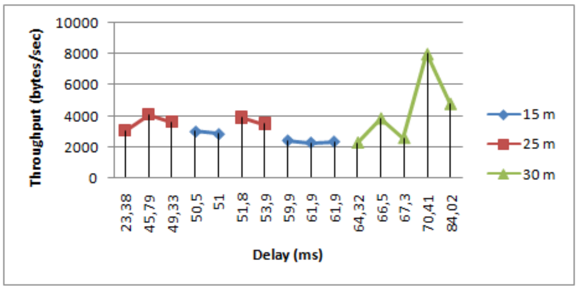

Figure 9. Throughput and delay testing chart with 1 user

According to the graph above it can be seen that the distance of observation is not affecting the throughput and delay. The observation at 30 m produces the greatest delay value. However the delay value at 25 m can be smaller than at 15 m. In the graph it can also be seen that when the delay becomes greater the value of throughput tends to shrink and the network performance becomes worse. It is caused by the delay of the wireless network. The delay is not only influenced by the distance but also the network error fluctuations, interferences, and environmental conditions.

Jitter values at these 3 distances are 64,408 ms, 53 ms and 74,328 ms and the packet loss is 0%.

4.3.3 Testing at the distance of 15 m, 25 m and 30 m with two users

Testing is conducted with 2 users on 3 different distances. The first user with IP 192.168.1.52 and the second user's IP 192.168.1.54. The goal of this testing is know network performance if both of users access the medical records or alarm almost simultaneously (the time difference is relatively small). Obstacle in this testing :

Table 4.7 Obstacle

User 2		
Jarak	Penghalang	Posisi
15 m	3 dinding triplek, pintu kaca, plapon	Di dalam ruangan
25 m	2 dinding beton, jendela kaca, plapon, koridor	Di koridor
30 m	3 dinding beton, jendela kaca, plapon, koridor	Di koridor
User 1		
Jarak	Penghalang	Posisi
15 m	Dinding triplek, 2 dinding beton, jendela kaca, plapon	Di dalam ruangan
25 m	2 dinding beton, jendela kaca, plapon, koridor lebih dominan	Di koridor
30 m	3 dinding beton, jendela kaca, plapon, koridor lebih dominan	Di koridor

In this test, the first user (192.168.1.52) access the web in seconds to 0,011079 which can be seen on the package 6. The second user (192.168.1.54) access the web in seconds to 0,698731 which can be seen on the package 16 so the time difference between these 2 users is

0,698731 - 0,011079 = 0,687652 second.

Then the last ACK just before the second user do the three way handshakes with the network shown in packages 12 and 14 so the time difference between these 2 packages is

0,632359 – 0,03205 = 0,600309 second.

Table 4.8 Delay Testing

Measurements	Delay (ms)					
	15 m		25 m		30 m	
	User 1	User 2	User 1	User 2	User 1	User 2
1	31,73	71,6	67,56	58,8	95,2	58,98
2	280	78	86,2	59	58,4	53,44
3	99,6	68,4	77,2	57,8	91,21	61,7
4	94,4	93,3	71,6	43,8	60	81,1
5	83,27	82,9	71,8	49,5	85,5	60,8
Total	589	394,2	374,4	268,9	390,31	316,02
Mean	117,8	78,84	74,87	53,78	78,062	63,204

On the table 4.8 above there are columns delay for user 1 and user 2. At a distance of 15 m delay occurred in user 2 is smaller than those of user 1. This is caused by the several walls as an obstacle. Server is placed in room N311 while the client is places at the distance of 25 m outside the room with only one obstacle. Laptop users placed outdoor at a distance of 30 m and the delay on the distance is greater than the distance of 25m.

Table 4.9 Throughput Testing

Measurements	*Throughput (bytes/sec)*		
	Distances 15 m	Distances 25 m	Distances 30 m
1	2292,323	3592,409	4803,075
2	2853,484	3073,317	2290,241
3	2431,025	3901,651	8024,036
4	3014,736	4075,014	3854,217
5	2356,633	3487,845	2594,364
Total	12948,201	18130,236	21565,93
Mean	2589,6402	3626,0472	4313,187

Table 4.10 Jitter Testing

Measurements	Jitter (ms)					
	15 m		25 m		30 m	
	User 1	User 2	User 1	User 2	User 1	User 2
1	38,8	96,3	68,5	71,4	128,6	79,7
2	320,5	120,4	87,3	70,1	78,7	57
3	132,5	90,5	103,3	77,2	115,6	67,5
4	140,7	121,4	97,8	56,2	85,8	74,6
5	99	115,9	95,2	62,6	116,9	77,6
Total	731,5	544,5	452,1	337,5	525,6	356,4
Mean	146,3	108,9	90,42	67,5	105,12	71,28

Table 4.11 Packet Loss Testing

Pengujian ke -	Jarak 15 m			Jarak 25 m			Jarak 30 m		
	A	B	*Packet loss(%)*	A	B	*Packet loss (%)*	A	B	*Packet loss (%)*
1	1016	1016	0	1535	1535	0	1358	1358	0
2	707	707	0	1720	1720	0	1316	1316	0
3	1808	1808	0	1062	1062	0	1106	1106	0
4	1311	1311	0	1296	1296	0	1333	1333	0
5	1032	1032	0	754	754	0	947	947	0

According to table 4.8 and 4.9 we can obtain comparison of throughput and delay in figure 4.4 below :

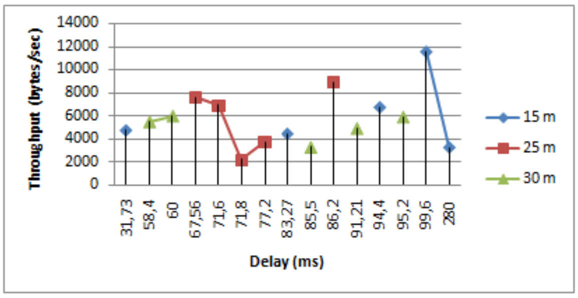

Figure 10. Comparison of throughput and delay of user 1

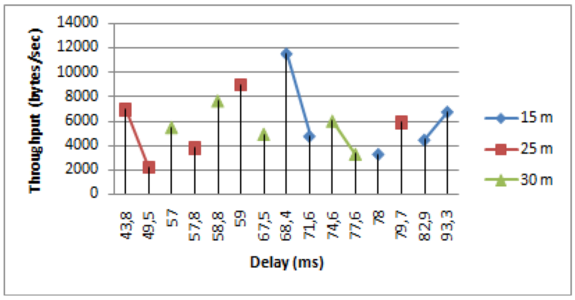

Figure 11. Comparison of throughput and delay of user 2

Based on figure 4.4 and 4.5 we can obtain information that in 15 m distances, delay is relatively large because the obstacle in this distance is more dominant than others. Jitter and packet loss testing in table 4.10 and 4.11 show the good performance according to TIPHON version.

V. CONCLUSION

This paper presents the design of RFID–microcontroller based wireless medical record. The analyzed QoS parameters show that the system can be applied to the patient care system in hospitals. In the future, a repeater should be installed to enhance the coverage area. As a suggestion, can be used more RFID reader for more user and this application should be in hospital as real application. In order to reduce system cost, a reader antenna multiplexer is needed for a RFID reader to support multiple patients.

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