DELAY ANALYSIS IN ZIGBEE WIRELESS COMMUNICATION FOR MANIPULATED DATA AND FINGER CLIP SENSOR DATA USING XBEE PRO S2C

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ABSTRACT

Wireless Personal Area Networks have battery powered, low data rate, and low cost, that have been researched in various fields, like Xbee Pro S2C. It can build mesh network, consist of Coordinator, Router and End Device. Xbee can perform point to point and multipoint communication. We evaluate delay performance and data loss for both communication at indoor environment, to get Xbee's successful transmission rate. This transmission sent the manipulated data and data from sensor finger clip by End Device Node as Tranmitter to Coordinator Node as Receiver. This data is sent with different interval time, 8ms for manipulated data and 500 ms for data finger clip sensor. Definition of Delay is the difference of difference of time between first data sent and first data received. From manipulated data measurement the delay of point to point is 1,17 seconds, whereas multipoint gets 1,332 seconds. For delay data finger clip measurement of multipoint is 1,34 seconds. While data loss occur in multipoint communication, for data finger clip measurement get the loss 53,33 % and 46,67% in random quartile of data, and for manipulated data get 3,56 % loss.

Keywords: *Wireless, Zigbee, Xbee, Heart Rate, Manipulated Data, Finger Clip*

1. INTRODUCTION

Wireless communication technology that widely used today is bluetooth and wifi. Bluetooth is one of the wireless personal area networks that have low speed with close range, this technology is still used for a particular purpose. Wifi technology has high data transfer rates and able to reach long distances, but this technology requires a large power consumption. In addition it is more expensive than bluetooth. There is also low-power wireless communication, which are currently being applied in agriculture and health field. It is called communication Zigbee protocol. In health field Xbee has used transmitting heart signals, but xbee cannot be sent them streamingly, because of its buffer memories [1]. But in [2] discussed the minimum sampling frequency of Xbee Pro SB3, that resolves buffer problem in Xbee.

Communication Zigbee refers to IEEE 802.15.4 standart, works on frequency 2,4GHz, 868 MHz and 915 MHz. It is devided by 16 channels. In [3] have analysed about the interference channel of Zigbee used Micaz. This paper concludes that Zigbee can be influenced by wifi, because of on the same frequency. Although Zigbee has 16 channels, they cannot be used, especially for Xbee. But Xbee just uses one channel [4], it is going to be easy for sending or receiving data at frequency 2,4GHz. Xbees search the channel and make sure that channel doesn't interference with the others.

Xbee has throughput 250Kbps and low latency, also build mesh network. Node that sends the data, called transmitter and node that receives the data called receiver. Xbee can be set as Coordinator, Router, and End Device. Coordinator scans the PAN ID and an available channel, whereas the Router and End Device scans the SC Channel dan search the valid coordinator. End Devices must be joined to parent (router or coordinator) before they can participate on zigbee network [5].

Zigbee transmission consists of three ways. They are transmitting data periodically, sending data in according the time interval set and sending data repeatedly with fixed speed. The transmitting process depends on the beacon

sent by the Coordinator. Each data transmission process, the coordinator always sends beacons to the nodes connected to it, if the transmission process is complete then the node will return to sleep mode, in this case the coordinator always on. Therefore sleep mode which conected with the coordinator, causes a span time between the nodes that transmit data with the node coordinator receiving the data. This time span is called Delay. Delay is defined as duration between sending a paket until its knowledgment packet has been received by the source[5]. In this paper, analyzing the delay of the data received at the source, for point-to-point and multipoint communication at obstacle and no obstacle environment. Delay affects the amount of data received by the Coordinator. In addition, the position of each node that communicate with each other affects data that arrived at the coordinator.

2. RESEARCH METHODE

The block diagram for proses transmission is shown in the figure 1 below,

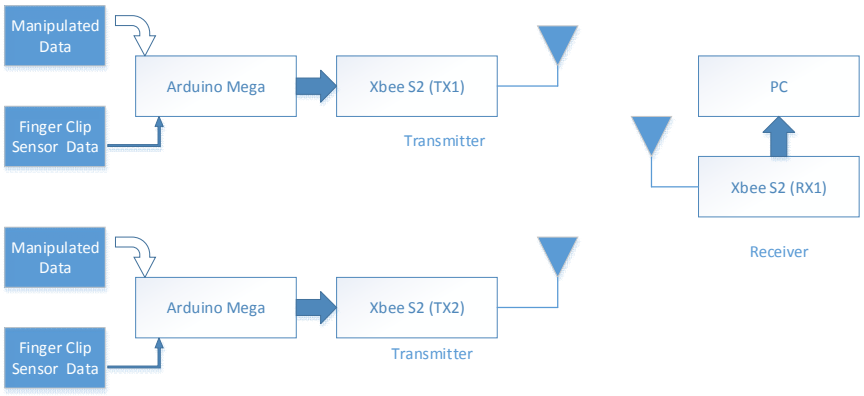

Figure 1. Block Diagram Sending-Receiving Data

Figure 1 shows the transmission process from Transmitters to Receiver where data sent is manipulated data and data from finger clip sensor. We set two of Xbee connect with Arduino Mega using xbee shield as node transmitter, however at the receiver, xbee conncet with the laptop and uses tera term application for saving the data. The Sensor Finger Clip, as I2C interface, is installed with Arduino Mega using grove cable.

The data are sent with different TX and RX positions, with the aim of analyzing the delay parameters as a result from the node position displacement. Scenario of the data transmission consists of the data and node position.

2.1 Data Scenario

The types of data sent are

2.1.1 Manipulated Data

Data manipulation is data of numbers transmitted with a certain pattern. The pattern has the purpose of ensuring that the data transmitted is received thoroughly by the receiver, to avoid the overflow of the receiving node, it is called data loss. The manipulation data consists of a set 3 digit and 9 digit characters, which are followed by enter characters. The manipulation data, sent 10 times, with an 8 ms interval.

2.1.2 Data From Finger Clip Sensor

Data is obtained from the detection O_2 levels in the blood using the Finger Clip sensor, this data is sent as a comparison against the manipulated data to ensure the correctness of data received in the coordinator. Data from Finger Clip Sensor has transmitted with interval 500ms.

2.2 Scenario Node Position

The transmission process of the two data is performed at indoors environment, which consists of several barriers namely barrier walls, cupboards, and iron windows. The barrier affects the data received at the receiving node. The node position scenario consists of two sketches, the first sketch shows the node position scenario on the first floor while the second sketch refers to the node position scenario on the second floor. The node positions of first sketch are 1-2_L, 1-4 , 1-2, 1-2-3, 1-2-4, 1-3-4, and 1-4-3. The node positions of second sketch are 5-6-7, 5-7-8, 5-6-9, 5-6-10, 5-7-10, 5-7-9, 5-8-9, and 5-8-10.

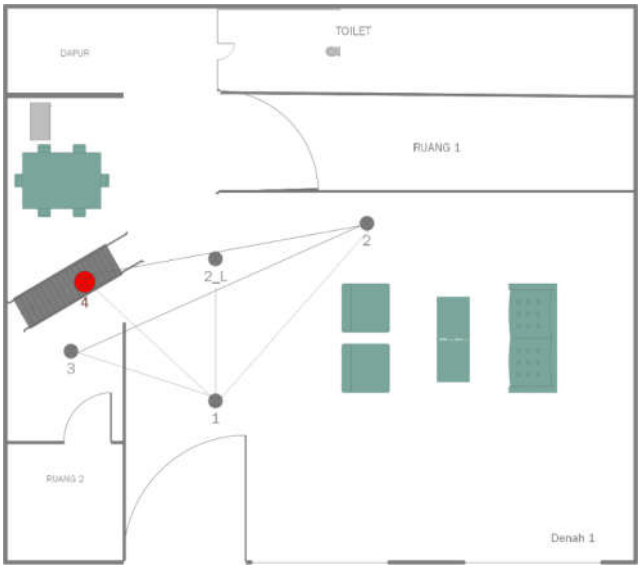

Figure 2. The First Sketch

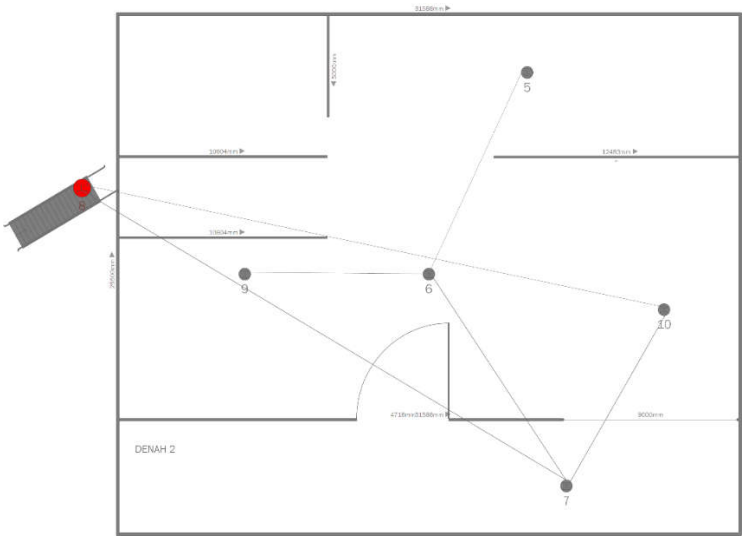

Figure 3. The Second Sketch

The first and second sketch illustrates the position of the nodes during the transmission process, it can be seen that there are obstacle around the nodes in the form of barriers, stairs, and cupboards, wooden doors and metal windows.

2.3 First Setting for Transmitter and Receiver Node

Setup for Xbee for this research is shown by Table 1.

Table 1. Xbee Setting

	Transmitter 2	Transmitter 1	Receiver
Node	End Device	Endevice	Coordinator
Baudrate	9600	9600	9600
PAN ID	1234	1234	1234
Scan Channel	F	F	7FFFF

The End Device node serves as the Sender while the Coordinator node serves as the receiving node acting as Parent of the nodes that will join it. The task of this Parent establishes a channel to communicate with other nodes by giving the same PAN ID address. Scan Channel is used as an addressing constraint of the End Device node to join a channel already established by the Coordinator.

3. RESULTS AND ANALYSIS

Based on Figure 1, data transmission is done two ways point to point and multipoint transmission.

3.1 Transmission Point To Point

In this case, one transmitter communicate with one receiver directly with sending manipulated data. The pattern of transmitted manipulated data is shown Table 2.

Table 2. The Transmitted Data

TX	**3 Digit**		**9 Digit**		**Total**	**Looping**	**Total Transmission**
	Numbers	**Enter**	**Numbers**	**Enter**	**Byte**		
1	400	1	1	1	1.610	10	16.100
						Total	**16.100**

Based on the transmitted data, it shows that the total of bytes sent is 16.100 bytes with interval data 8 ms. While the data received is shown by Tabl 3.

Table 3. The Received Data

Node Position	The numbers of transmitted data (Byte)	The numbers of received data (Byte)	Loss(%)	Delay (seconds)	The time data received (seconds)
1-2L	16.100	16.100	0%	1,25	34,17
1-2	16.100	16.100	0%	1,205	34,125
1-4	16.100	16.100	0%	1,25	34,56
Average				1,235	34,285

Based on the result of point to point measurement in accordance with the position of node on Figure 1, showing the average delay of 1,235 seconds with the average time of data received entirely in receiving node about 34,285 seconds. It denotes the transmission process is blocked by cupboards of wood and walls.

After sending the data manipulation in the form of numbers, then the next step is to send data from the finger clip sensor results. This data is obtained from O_2 levels in human blood, using I2C data can be read by arduino micro and via serial communication with Xbee, the data can be transmitted to receiver. The interval of each data sent is 500ms with a long observation of 1 minute or 60 seconds, so the data received in one minute is 240 data consisting of 120 data from the first sender and 120 data from the second sender. The transmission is shown by Table 4.

Table 4. The Received Data of Finger Clip Sensor

Node Position	Transmitted Data	Received Data	Loss(%)	Delay (seconds)	The time data received (menit)
1-2_L	120	120	0%	1,215	1
1_2	120	120	0%	1,295	1
1_4	120	120	0%	1	1
		Average		1,17	1

From Table 4, the transmission of data from sensor is delayed 1,17 seconds, where the data is observed for one minute. The receiver is able to receive all the received data both from the transmitter. The order of received data is the same as the data sent. The truth of the data sent is the same as the data received, there is no loss, it is related to the time interval between data sent or commonly referred to as the sampling interval. The sampling interval provided is 500ms. However due to the distance between TX and RX that makes the received data delay.

3.2 Transmission Multipoint

Multipoint Transmission is a transmission that involves two transmitters with one receiver. It sends manipulated data and data from finger clip sensors. There are two of transmitter, that send the different data. TX1 transmit characters number 100 until 499 in a packet, whereas TX2 send 500 untill 999 numbers in a packet. We sent five packets in same time to the node receiver. These packets were accepted randomly by receiver, so all of data can detect correctly. This can make be easier for doing analyze the data. The detail of data is described in Table 5.

Table 5. The Data Sent of Multipoint Scenario

Transmitter	**3 digit**		**9 Digit**		**Total Byte**	**Packet**	**The Total of data**
	Number	**Enter**	**Number**	**Enter**			
1	400	1	1	1	1.610	5	8.050
2	500	1	1	1	2.010	5	10.050
						Total	**18.100**

Receiced Data is shown by Table 6, it can be seen that the data received by the coordinator experiencing loss and delay. Loss occurs due to the 8 ms sampling interval of transmitted data, thus allowing the accumulation of data received from TX1 and TX2. In addition, other causes of loss occur are distance and obstacles. The average loss is 3,56% and the average delay is 1,320 seconds and the time all data received is 27,274 seconds. After the data manipulation, then the data sent next is the data from the finger clip sensor, the measurement results are shown at the Tabel 7.

Table 6. The Data Sent of Multipoint Scenario

No	Node Position	Transmitting	Receiving		Percentage		Delay (seconds)	The time data received (menit)
		The Transmitted Data	The Received data	Loss	The Received Data in persen	Loss in Persen		
1	1 - 2 - 3	4.510	4.392	153	97,38%	3,39%	0,840	27,43
2	1 - 2 - 3	4.510	4.288	291	95,08%	6,45%	0,470	27,18
3	1 - 2 - 4	4.510	4.509	51	99,98%	1,13%	1,370	27,74
4	1 - 2 - 4	4.510	4.395	151	97,45%	3,35%	1,460	27,18
5	1 - 3 - 4	4.510	4.287	264	95,06%	5,85%	1,680	27,29
6	1 - 3 - 4	4.510	4.510	56	100,00%	1,24%	1,200	26,98
7	1 - 4 - 3	4.510	4.390	171	97,34%	3,79%	1,790	27,17
8	1 - 4 - 3	4.510	4.394	147	97,43%	3,26%	1,750	27,22
		Average	**4.396**	**161**	**97,46%**	**3,56%**	**1,320**	**27,274**

The results of measurements made on the first sketch and the second sketch indicate that the average delay is 1,34 seconds. Sampling interval of 500 ms data transmission with time duration of observation is 1 minute, able to be accepted by Coordinator. Data from Transmitter1 and Transmitter2 are received intactly by the Coordinator, but the data is not received simultaneously. The table shows that the data received by the Coordinator can not be received simultaneously, but the data is received in full.Therefore we make the quartil of data to know the error of data. We devided 240 data, it consists of 120 data came from TX1 and 120 data came from TX2, be fourth quartil. Each quartile of data to 60, 120, 180, and 240 indicates the matching of data received with data sent.

Observation of each Quartile explicate the possibility of loss. For example at the position of node 5-6-7, Coordinator received 53.33% correct data on the first quartile of TX1, whereas from TX2 received 46.67% data on the first quartile. Because the observation is done 1 minute, Coordinator able to accept all data sent.

Table 7. The Data Received From Multipoint Scenario

	Node	TX1				TX2				Delay
No	Position	60	120	180	240	60	120	180	240	seconds
1	5-6-7	53,33%	50,00%	50,00%	50,00%	46,67%	50,00%	50,00%	50,00%	1,43
2	5-6-7	46,67%	53,33%	50,00%	50,00%	53,33%	46,67%	50,00%	50,00%	1,12
3	5-7-8	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	1,48
4	5-7-8	46,67%	50,00%	50,00%	50,00%	53,33%	50,00%	50,00%	50,00%	1,40
5	5-6-9	46,67%	50,00%	50,00%	53,33%	53,33%	50,00%	50,00%	46,67%	1,10
6	5-6-9	46,67%	50,00%	50,00%	53,33%	53,33%	50,00%	50,00%	46,67%	1,42
7	5-6-10	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	1,14
8	5-6-10	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	1,43
9	5-7-10	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	1,28
10	5-7-10	50,00%	50,00%	46,67%	50,00%	50,00%	50,00%	53,33%	53,33%	1,16
11	5-7-9	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	1,41
12	5-7-9	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	1,77
No	Node	TX1				TX2				Delay

	Positions	60	120	180	240	60	120	180	240	
13	5-8-9	53,33%	50,00%	50,00%	53,33%	46,67%	50,00%	50,00%	46,67%	1,18
14	5-8-9	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	1,40
15	5-8-10	50,00%	50,00%	50,00%	53,33%	50,00%	50,00%	50,00%	46,67%	1,29
16	5-8-10	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	50,00%	1,42
									Average	1,34

4. CONCLUSION

From the indoor measurement using Xbee Pro S2C indicate that the position of Transmitter and Receiver nodes affect the data transmission process, as evidenced by the existence of data loss and delay from the transmitting. Based on the observation of each delay scenario for manipulated in point to point measurement is 1,17 seconds, while for multipoint measurement is 1,332 seconds. Whereas for data finger clip get delay is 1,34 in communication multipoint. Howerver data loss only occur in multipoint communication, for data manipulated get 3,56% loss and data finger clip sensor 53,33% until 46,77 % from random quartile.

REFRENCES

[1] Jusak, Puspasari., I . (2015) Wireless tele-auscultation for phonocardiograph signal recording through Zigbee networks, IEEE Asia Conferense on Wireless and Mobile (APWiMob). Surabaya. Indonesia. pp 95-100

[2] Reyna, M.A. Avitia. R.L. amd Bravo. M.E. (2017) Wireless ECG Electrodes using Xbee PRO S3B, Global Medical Engineering Physics Exchanges/Pan American Health Care Exchange (GMEPE/PAHCE). Tuxtla Gutierrez,Mexico

[3] Ahmed.N., Kanhere.S.,Jha.S. (2009). Multi-Channel Interference in Wireless Sensor Networks. IPSN'09 Proceedings of the 2009 International Conference on Information Processing in Sensor Networks. San Fransisco, California, USA.

[4] X-CTU Configuration and Test Utility Software : User's Guide Digi International Inc., Aug.2008

[5] Mayalarp.V, Limpaswadpaisarn.N, Thanachai Poombansao, and Kittipiyakul.S.,(2014). Wireless Mesh Networking with Xbee. ECTI Internasional Conference on Electrical Engineering/Electronics, Computer, Telecommunication and Information Technology