VOL. 10, NO 20, NOVEMBER, 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

THE EFFECT OF MESH NETWORK ON ECG DATA TRANSMISSION BY XBEE TOWARD THE DATA ERROR RATE

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ABSTRACT

Wireless Sensor Node technology based on XBee radio can support peer-to-peer network topology, cluster tree and mesh. Implementation of network topology must be adjusted to the needs. The study conducted a comparative between peer to peer topology and mesh toward the behaviour of the data transmitted by electrocardiogram signal data acquisition device. The purpose is to determine the performance of XBee in real time application. After 4 scenario tests obtained, error happened when two or more nodes are connected to the coordinator with the numbers of average error for 1,000 data is 0.4 - 2.7. The other facts, error happened randomly and not linear with the number of sensor nodes.

Keywords: mesh network, Xbee, ECG, error rate.

1. INTRODUCTION

Multipoint applications or multiuser monitoring centralized system has been developed; one was applied on health service in hospitals. This monitoring system was applied to monitor the health condition of a patient who requires intensive care. One of the important parameters that describe someone's health is his heart condition that acquired using the ECG device.

Previous research had conducted a study to monitor the condition of the heart using Android via WLAN [1]. Another study by Radian Sigit made a mini wireless of ECG to monitor the heart's condition of athletes via Bluetooth [2]. The using of WLAN and Bluetooth will facilitate the development because it does not require additional software on the receiver since the module has been integrated on PC or smart phone; but it will be hard to apply on robust network for configuration settings on both modules. XBee module presents to solve the problem because it has the simple configuration for different network models and low power consumption.

Research by A.R. Fikar, *et al* realize the PC based Wireless Vital Sign Monitor using ZigBee Communication with peer-to-peer configuration [3]. Almost similar research for vital signal monitoring system presented in [4]. The other study by Sugondo [5] had applied the ECG monitoring system for multi-user by using a mesh topology. However, both of the research was not discussed about the data behaviour on the network. After further observation and analysis, it found a problem on the mesh network application on XBee for real time data; the emergence of data errors. Therefore, this study discussed the rate of data errors on ECG monitoring application that had been done in previous studies. The results of this study can contributed to WSN study in real time applications and be a solution for the next study.

There are some main contents of this paper; section II presents the description of the ECG, Mesh Topology, ZigBee and Error Rate. Section III describes briefly about the system design and implementation. Result and discussion are described in section IV followed by Conclusions in section V.

2. THEORY

2.1 Electrocardiograph

Electrocardiograph (ECG) is a device that used to record the ECG signal [6]. Transcription of the electrical activity produced by the heart muscles is called an electrocardiogram or ECG signal. The normal ECG's form can be seen in Figure-1.

In this study, the device to record ECG signals placed on each node that integrated with a micro-controller as a medium for sending data to the coordinator via XBee. It will be discussed more clearly in section 3.

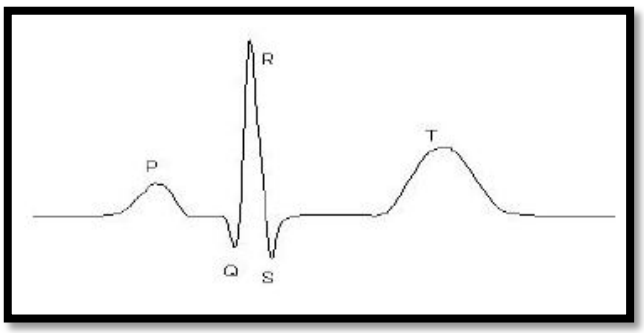

Figure-1. Normal ECG signal [7].

2.2 Mesh topology

On the mesh network, every node can communicate each other. Other characteristics are a router and radio coordinator. These radios can pass messages along to other routers and end devices as needed [8]. Node end devices may be attached to any router or to the coordinator.

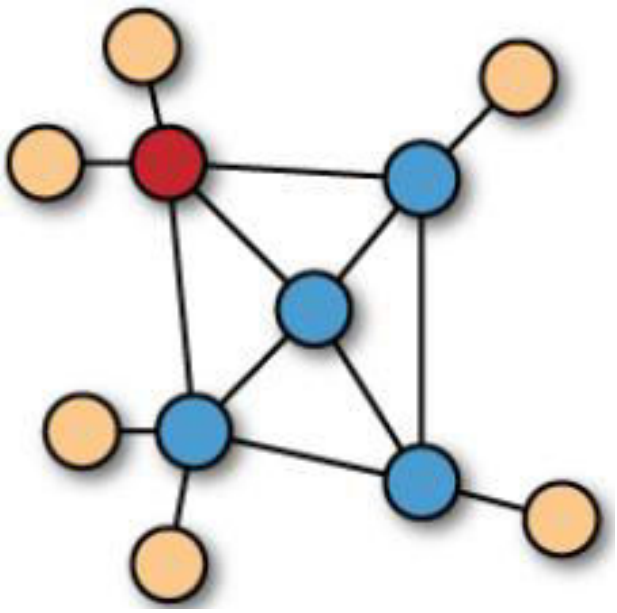

Figure-2. Mesh topology [8].

A. XBee

X-Bee is a transceiver radio device that uses the protocol of IEEE 802.15.4 called ZigBee as the basis of communication standard [5]. XBee is chosen due to the simple configuration for different types of network topologies, for instance are mesh and low power consumption. XBee module can work as a coordinator, router or end device. The most interesting point from XBee is found a routing protocol which embedded in the module that allows developers to implement the network model.

B. Error rate

In digital transmission, the error rate is defined as the amount of error data that received because of noise, distortion interference or synchronization bit error. The focus of this study is to calculate the Bit Error Rate and Data Error Rate. Bit error rate means the number of digital bits that is "0" on the transmission network received as a state of "1" or in contrast, then divided by the number of bits that transmitted or processed during the specified period. Data error rate means an error while reading the data characters by dint of bit errors. For instance: the data submitted with the value of 50, and then the receiver section read it as 45. Data error rate follows the following equation:

$$\text{Data error rate} = \frac{\text{numbers of data error}}{\text{numbers of data sent}} \quad (1)$$

3. SYSTEM DESIGN

From Figure-3, Four (4) pieces of sensor nodes which function to record the ECG signal were connected to XBee End Device and router, while a coordinator was connected to the PC as a processor central and signal data viewer. The ECG nodes could communicate each other. The

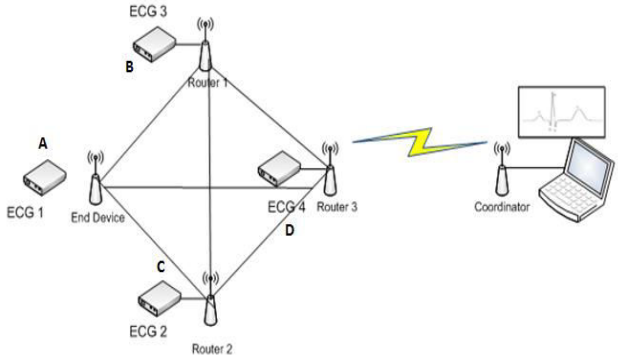

Figure-3. System implementation.

decision process of communication lines are carried by all router nodes. There was no special program for routing process because algorithms and protocols were already embedded in the XBee module. The XBee configurations are as follows:

Table-1. Configuration of XBee.

X-Bee 1 set as coordinator AT	
PAN ID	PAN ID all of node
SH Address	DH all *routers* and *end device*
SL Address	DL all *routers* dan *end device*
X-Bee Router (1,2 and 3) set as Router AT	
PAN ID	PAN ID all *node*
DH Address	SH Coordinator
DL Address	SL Coordinator
X-Bee End Device set as End Device AT	
PAN ID	PAN ID all *node*
DH Address	SH Coordinator
DL Address	SL Coordinator

4. TESTING AND RESULTS

The object of this study is to find out the effect of the mesh network to the data error rate and the result is expected to give recommendation for the next study. The tests to determine the effects were done as follows:

a) A coordinator node only communicates with another 1 node,

b) A coordinator node communicates with another 2 node,

c) A coordinator node communicates with another node,

d) A coordinator node communicates with all nodes.

In the next test, each of nodes acquired the ECG signals and then the data was sent to the coordinator. The test was done in some steps; first, only node D which sent the data followed by node C, then node B and A did. The results can be seen on Figure-4 as follows:

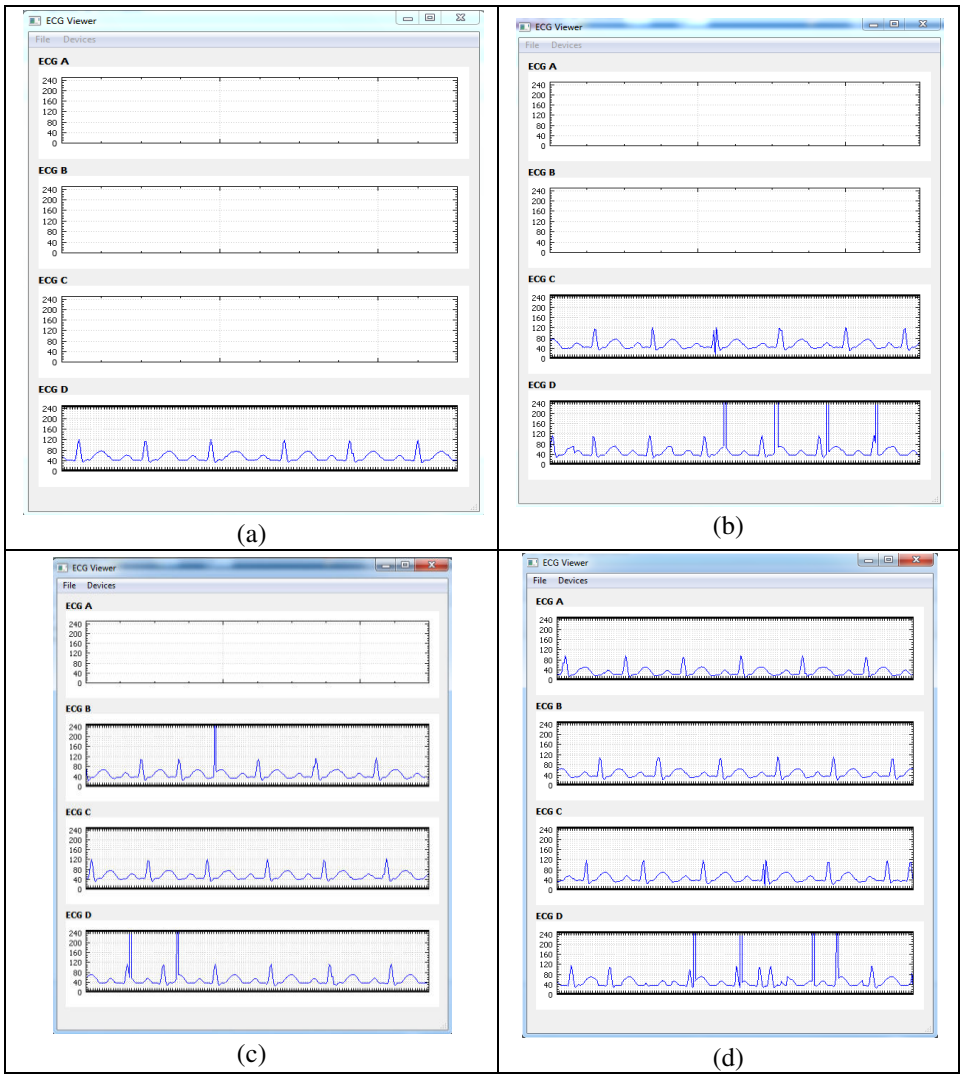

Figure-4. (a) Data from node D (b) Data from node C, D (c) Data from node B, C, D d) Data from node A, B, C, D.

It can be seen from the graphic above that there was a data error if the two nodes or more communicated with coordinator. The data error caused the graphic representation of ECG signals was inappropriate. The data errors were random for every node; it means that each of nodes could experience an error either alternately or simultaneously.

The tests of data error rate were done by looking at the errors of integer data that received in every 1,000 data with the total observation data as 10, 000; and then based on the error rate, it could be determined the result of BER.

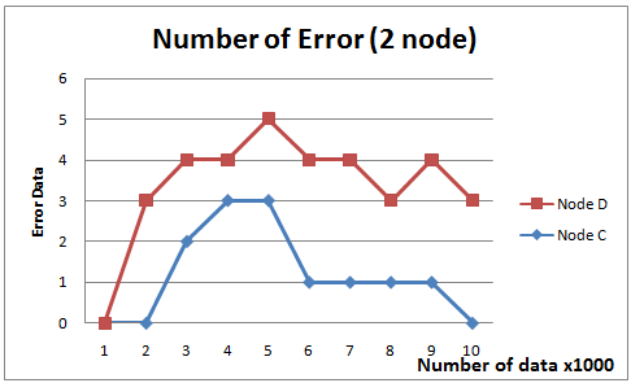

Figure-5. Number of error (2 Node Active).

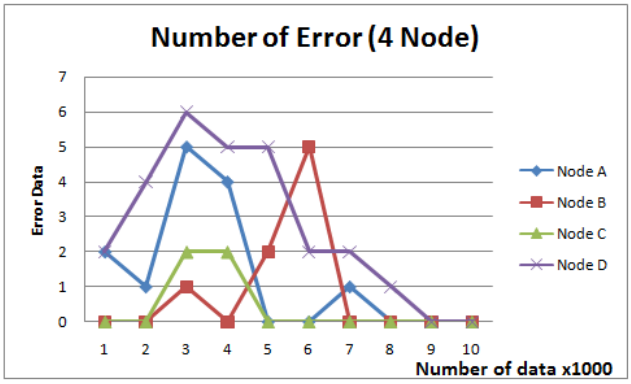

Figure-7. Number of error (4 Node Active).

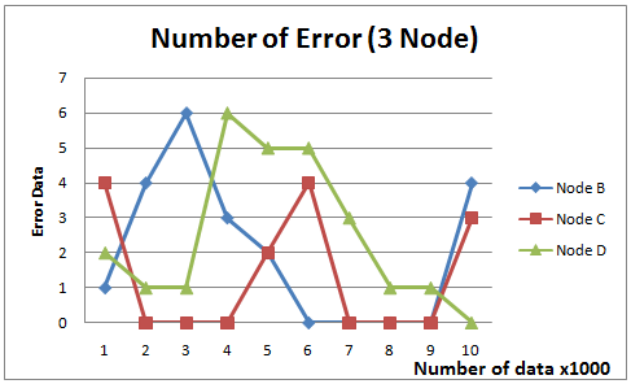

Figure-6. Number of error (3 Node Active).

Table-2. Average error and % error for 10,000 data.

No.	Number of node	Name of node	Total error of data	Average error	% Total error (for 10000 data)
1	1	Node D	0	0	0
2	2	Node D	22	2.2	0.22%
		Node C	11	1.1	0.11%
3	3	Node D	25	2.5	0.25%
		Node C	13	1.3	0.13%
		Node B	20	2	0.20%
4	4	Node D	13	1.3	0.13%
		Node C	8	0.8	0.08%
		Node B	4	0.4	0.04%
		Node A	27	2.7	0.27%

It can be seen based on the results; the average of data error rate was relatively small for every 1,000 observational data (see Table-2). The maximum number of data error was occurred when the coordinator connected with 3 nodes and 4 nodes with 6 as the maximum data error rate (see Figure-6 and Figure-7). The data error rate were random, there was no relation between the numbers of nodes with the linearity error. It can be seen in Table-2, the percent of error average maximally occurred when the coordinator was connected with 3 nodes, and minimally occurred when the coordinator was connected with 4 nodes.

5. CONCLUSIONS

It obtained some conclusions after the realization and performance tests on ECG monitoring applications by using mesh network scheme were conducted, namely; the using of mesh network on real time application of ECG monitoring gave an impact on the error data, the numbers of average error for every 1,000 data was 0.4 - 2.7, it means that every node will pass an error for every 1,000 integer sent. The error rate occurred randomly, there was no guarantee whether more nodes caused a greater error value or not. The results showed that the average of the maximal error occurred when 3 nodes worked, but in contrast, 4 connected nodes will produce the minimum error rate. The condition is not suitable for real time monitoring application of human vital signal because it will cause the error in data representation. The further study is needed to solve the problem and to make the error correction of algorithm by using mathematical analysis or prediction.

REFERENCES

[1] Rizal A, *et al*. 2012. Development of Multisignal Remote Patient Monitoring System for Heart Patient using Android Based Tablet PC and Wireless LAN (IEEE.802.11.B/G). Jurnal Penelitian and Pengembangan Telekomunikasi, IT Telkom. Vol. 17.

[2] Sigit R, *et al*. 2014. Mini Wireless ECG for Monitoring Athletes' ECG Signal Based on Smartphone. IOSR Journal of Engineering (IOSRJEN). 04: 13-18.

[3] Fikar A.R, *et al*. 2013. PC Based Wireless Vital Sign Monitor Using ZigBee Communication. The 15th International Conference on Biomedical Engineering, IFMBE Proceedings. 43: 904-907.

[4] D. Hanita D., I. G Nurul Fauzana., M. N. Nursyarizal., I. Taib I. 2015. A Zigbee-Based Continuous Online Vital Sign Monitoring System. ARPN Journal of Engineering and Applied Sciences. 10(2): 391-395.

[5] S. Hadiyoso, R. Mayasari. 2014. Monitoring Elektrokardiograf Menggunakan Topologi Mesh. Jurnal Elektro dan Telekomunikasi Terapan, Universitas Telkom. Vol. 1.

[6] Rizal A. 2013. Instrumentasi Biomedis. Graha Ilmu, Bandung, Indonesia.

[7] W. J. Tompkins. 199. Biomedical Signal Processing. Prentice Hall, New Jersey, USA.

[8] Faludi R 2010. Building Wireless Sensor Networks. O'Reilly Media, Sebastopol.