

Efficient Routing Technique in a Wireless Sensor Network using Personal Area Network and Artificial Neural Method

¹James Agajo, ²Okeke Benjamin Chukwujekwu, ³Awolo C.I., ⁴Igbinosun Osayomwanbor Micheal

¹ Department of Computer Engineering Federal University of Technology, P.M.B 65 Minna, Nigeria

²Department of Information Management Technology, Federal University of Technology Owerri Imo State

³Department of Electrical/Electronic Engineering Auchi Polytechnic Auchi, Edo State

⁴Department of Computer Engineering, Shaka Polytechnic Benin City Edo State

Abstract

Efficient routing technique and localization in a Wireless Sensor Network describes how multiple wireless sensing nodes can be effectively addressed and arranged within a Personal Area Network (PAN) in a Wireless Sensor Network. The method involve creating multiple PAN in the network to be coordinated by a Full Functional Device called coordinator, the rest nodes in the PAN are referred to as reduced functional device (RFD), to achieve this the nodes were patterned in the order of an Artificial Neural network (ANN), which gave rise to an a maximum of 65025 sensor nodes that can be addressed. This method made it possible for data (payload) transmitted by each node to be received by the specific receiving node at the destination with the aid of node addresses.

Keyword: PAN, FFD, RFD, Routing, Payload

1.0 Introduction

The ease of deployment offered by wireless sensor networks often comes with a lack of precise localization. Short of using an absolute positioning system, such as GPS, to position and monitor each node, knowing a definite location for a node is a challenge.

The goal of this paper is to affirm the address of the sensor node and also used to detecting faulty node, locate the faulty sensors in the wireless sensor networks node addressing method. We propose and evaluate a localized node detection algorithm to identify a particular sensor node. The implementation complexity of the algorithm is low and the probability of correct diagnosis is very high even in the existence of large fault sets.. Due to the low cost and the deployment of a large number of sensor nodes in uncontrolled or even harsh or hostile environments, it is not uncommon for the sensor nodes to become faulty and unreliable. The networks must exclude the faulty sensors to ensure the network quality of service. To identify the faulty sensor nodes is not trivial at all because of the existing challenges. Sensor nodes are powered by batteries, which are considered as limited

resources. It is very expensive for the base station to collect information from every sensor and identify sensors in a centralized manner. Different applications may require the sensor node detection to be conducted in a real-time mode with low latency or high throughput. Therefore, a localized and distributed generic

Algorithm for each node is highly preferred in wireless sensor networks. [6]

Cluster head method is not being used here, but rather a neural network arrangement that patterns the nodes in a linear form.

2.1 Neural Network Wireless Sensor Network Topology

In the neural network arrangement each node transmit from one sensor node to the other in a personal area network, the node within the network is called reduced functional device (RFD), a sink node called the full functional device (FFD) manages the network, which is the destination where the final data transmitted resides.

This work adopts the forward propagation method where the nodes are referred to as Reduced Functional Device while the FFD is referred to Full Functional Device.

We come up with a design where weight w and input x are the source variables

$$X_1 - W_1$$

$$X_2 - W_2$$

$$X_3 - W_3$$

A forward propagation technique will require a transition for the neural set considering the values of x as input and W as weight as in equation 1.

$$\left. \begin{array}{l} X_{11}W_1 - X_{12}W_2 - X_{13}W_3 \dots \dots X_{1n}W_n \\ X_{21}W_1 - X_{22}W_2 - X_{23}W_3 \dots \dots X_{2n}W_n \\ X_{31}W_1 - X_{32}W_2 - X_{33}W_3 \dots \dots X_{3n}W_n \\ \vdots \\ X_{m1}W_1 - X_{m2}W_2 - X_{m3}W_3 \dots \dots X_{mn}W_n \end{array} \right\} \quad (1)$$

This work refers to reduced functional device RFD as the source which is the input and the full functional device FFD as the sink. We therefore substitute the input x in the neural set as R while FFD is substituted for F as in equation 2.

$$\left. \begin{array}{l} R_{11}W_1 - R_{12}W_2 - R_{13}W_3 \dots \dots R_{1n}W_n \\ R_{21}W_1 - R_{22}W_2 - R_{23}W_3 \dots \dots R_{2n}W_n \\ R_{31}W_1 - R_{32}W_2 - R_{33}W_3 \dots \dots R_{3n}W_n \\ \vdots \\ R_{m1}W_1 - R_{m2}W_2 - R_{m3}W_3 \dots \dots R_{mn}W_n \end{array} \right\} \quad (2)$$

The neural set above directly substitute X for R and the following matrix represents the solution for the equation (3)

$$\begin{bmatrix} R_{11} & R_{12} & R_{13} & \dots & R_{1n} \\ R_{21} & R_{22} & R_{23} & \dots & R_{2n} \\ R_{31} & R_{32} & R_{33} & \dots & R_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ R_{m1} & R_{m2} & R_{m3} & \dots & R_{mn} \end{bmatrix} \begin{bmatrix} W_1 \\ W_2 \\ W_3 \\ \vdots \\ W_n \end{bmatrix} = \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ \vdots \\ F_n \end{bmatrix} \quad (3)$$

The Matrix in (3) can be modelled in the form of the logical linear progression topology as shown in figure 1.

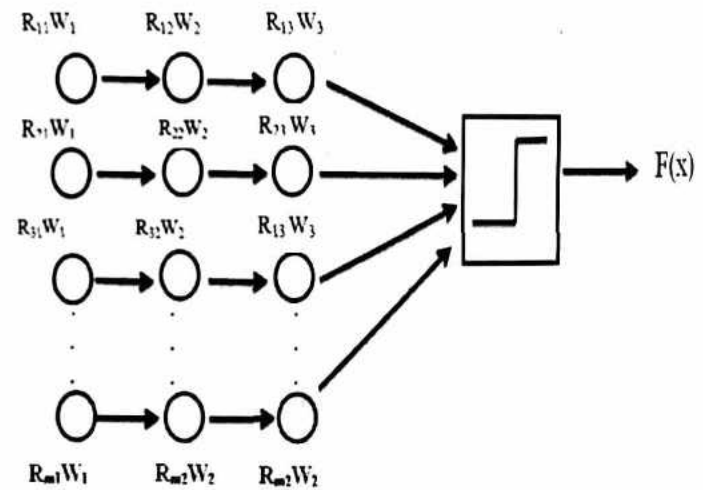


Figure 1 Artificial Neural Network Model WSN

Inter node data transmission is made possible by the node address, that is for data to be transmitted between nodes their respective addresses and their payload will be noted, thereby arranging the node in the network. To follow a particular routing protocol, a particular route is characterized by column which is the PAN (Personal area network), while the row represent the next route.

The node in the row will involve picking on the nodes column after column in a particular row that is $R_{11}, R_{12}, \dots, R_{1n}$, while the last row will involve $R_{m1}, R_{m2}, \dots, R_{mn}$.

This work presents Column = inner loop while row = outer loop.

The recursive equation for the inner loop which stand for the column will be the first to be executed before that of the outer loop which is the row as represented by equation 4.

$$\text{Inner loop} = \sum_{i=1}^n R_i \quad (4)$$

$$\text{outer loop} = \sum_{j=1}^m R_j \quad (5)$$

R_i is node parameter like data and address is shown in figure 5.

overall nodes in the network

$$= \sum_{j=1}^m \sum_{i=1}^n R_{mn} \quad (6)$$

A node sequence reading algorithm and flowchart is shown in figures 2 and 3.

Start

Dimension Sensor node(n) in PAN

Dimension Sensor node Address(n)

Dimension Sensor node Address(n)

Count(j)=+1

Count(i)=1

Read transmit Payload within Sensor node in PAN

Read Sensor node Address

Count(i)=i+1

i ≥ m

receive and send acknowledgement between node

Count(i)= Count(i) +1

Count(i) ≥ max

next PAN

Figure 2: Node Routine Algorithm

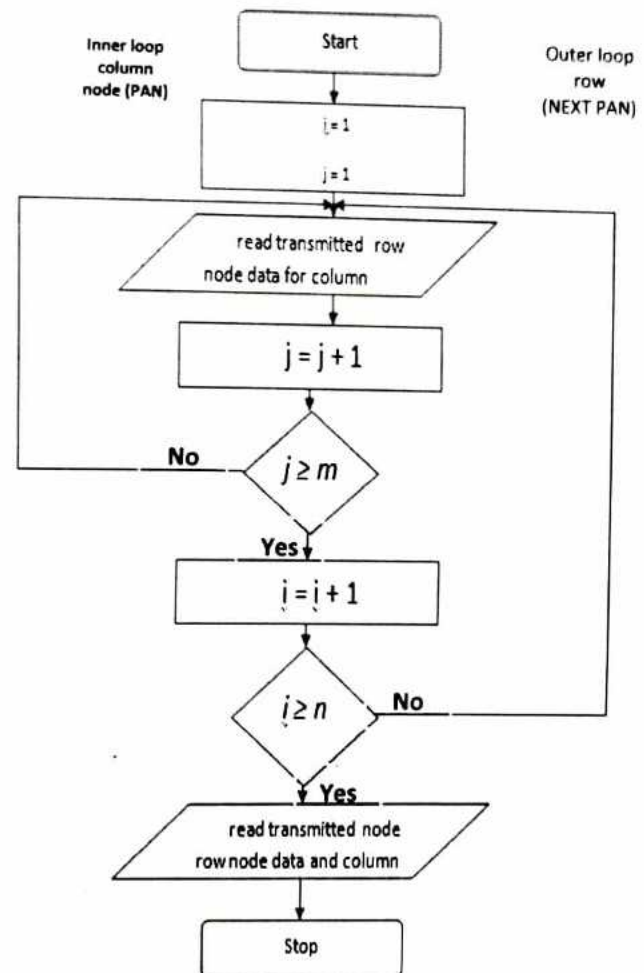


Figure 3 Flowchart of node transmission sequence

3.0 Personal Area Network and FFD

A Personal Area Network (PAN) is evolved by coming up with a sink node head called Full Functional device (FFD) which manages its own network within a PAN. The PAN is an array of node arranged in an ordered form to transmit data from one node to another within a particular PAN as shown in figure 4, 5 and 6. The structure is arranged in matrix form to transmit data. This work employs a transmit and receive after acknowledging the source and sink addresses respectively. This communication system simply send data when it has data ready to send and then waiting for an acknowledgement.

Calculating Addressable Sensor Node in a 8 Bit System, the total number of addressable node in the PAN is $2^n - 1$

Let $Y = 2^n \dots 6$

For an 8 bit processor, $n = 8$

Total number of addressable node in a node in the PAN is $Y - 1$ for an 8 bit processor machine.

PAN addressable node is $2^n - 1 = 255$

$n = 8$ number of bit for processor

The eight node in the PAN network is made to communicate with each other, with the last node been the sink node in the network this is considered the column.

For total number of addressable node in the network ,

A total of 8 PAN will be needed for the entire network

For the entire network the total number of node is

$(Y - 1)(Y - 1)$. Since $Y = 2^n$, the total number of nodes is

$$(2^n - 1)(2^n - 1) \\ = 255 \times 255 = 65025$$

in a Wireless Sensor Network is 65025

$$(2^n - 1)(2^n - 1) \\ = (Y - 1)(Y - 1) = Y^2 - 2Y + 1$$

Maximum number of addressable node for 8 bit processor

$$= (2^n)^2 - 2(2^n) + 1 \quad (7)$$

$2^{2n} - 2^{n+1} + 1$ formular represents the maximum addressable node in the network with 8 bit processing machine.

3.1: Node Keying and Addressing Technique

- **PAN Address is the sink node**
- **Device Address is the normal soucre nodes**

$$[\text{PAN Address}] [\text{Device Address}] = [\text{Location}]$$

Figures 4, 5 and 6 are matrix representation of sensor node in the field at the end of each PAN is the overall sink node.

0,0	1,0	2,0	3,0	4,0	5,0	6,0	7,0	8,0	254,0	255,0
0,1	1,1	2,1	3,1	4,1	5,1	6,1	7,1	8,1	254,1	255,1
0,2	1,2	2,2	3,2	4,2	5,2	6,2	7,2	8,2	254,2	255,2
0,3	1,3	2,3	3,3	4,3	5,3	6,3	7,3	8,3	254,3	255,3
...	...	...	...	...	...	...	...	...	...	...
254,0	254,1	254,2	254,3	254,4	254,5	254,6	254,7	254,8	254,254	255,255
255,0	255,1	255,2	255,3	255,4	255,5	255,6	255,7	255,8	255,254	255,255

Figure 4: WSN network matrix

0,0	1,0	2,0	3,0	4,0	5,0	6,0	7,0	8,0	254,0	255,0
0,1	1,1	2,1	3,1	4,1	5,1	6,1	7,1	8,1	254,1	255,1
0,2	1,2	2,2	3,2	4,2	5,2	6,2	7,2	8,2	254,2	255,2
0,3	1,3	2,3	3,3	4,3	5,3	6,3	7,3	8,3	254,3	255,3
...	...	...	...	...	...	...	...	...	...	...
254,0	254,1	254,2	254,3	254,4	254,5	254,6	254,7	254,8	254,254	255,255
255,0	255,1	255,2	255,3	255,4	255,5	255,6	255,7	255,8	255,254	255,255

Figure 5: Node Location Address Routine

D0,0	D1,0	D2,0	...	D254,0	P255,0
D0,1	D1,1	D2,1	...	D254,1	P255,1
D0,2	D1,2	D2,2	...	D254,2	P255,2
...	...	...	...	...	...
D0,255	D1,255	D2,255	...	D254,255	P255,255

Figure 6: Device Matrix

Figures 4, 5 and 6 represent the matrix arrangement of RFD, PAN for the wireless Sensor nodes, while figure 6 is for the matrix in the field,

Table 1: Address allocation table

S/N	DEVICE	PAN	NODE LOCATION ADDRESS	ADDRESS CODE
0.	D00	P255,0	D00 P255,0	00000000
1.	D01	P255,1	D01 P255,1	00000001
2.	D02	P255,2	D02 P255,2	00000010
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
255	D255	P255	D255P255,255	11111111

Figure 5 stands for the process of obtaining the result from dot product while figure 6 then result of the dot product is the address describing the location of the node location address.

Table 1 shows the resulting node location which assigns an address after combining device and PAN together to get location and address of the node.

4.0 Routing Implementation

Simple 8-bit processors like an 8051, AT-MEGA 8 was made to handle this chores easily. Here the node is made to transmit data only when there is data to be transmitted, we adopt a sleep/active mode technique as we consider the excess circuit associated with Clustering Head method for multiple nodes; in such cases the data header generally contains addressing information so that the data is received by the correct host node. Typically, two addresses are included, the destination address, which is where the packet is intended to go, and the transmitter's address which is necessary if there is to be a reply sent. In addition, other fields may be present, to identify the particular applications that are running on the network host that are sending and waiting for data.

The system is design such that data is transmitted from one node to other node by taking note of the address of node for which data will be transmitted.

The source address is noted and the destination address is also noted, the data is then transferred

after acknowledgement has been made. An initial design is shown in Table 2

Table 2: Frame Structure

SOURCE ADDRESS	DESTINATION ADDRESS	PAY LOAD
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The source address is for the address of the source none while the destination address stand for the address of node at the destination.

Simulations using PROTEUS LABORATORY showing a Full functional Device (FFD) and Reduce Functional Device (RFD) to realize Artificial Neural Network are shown in Figs 7 and 8.

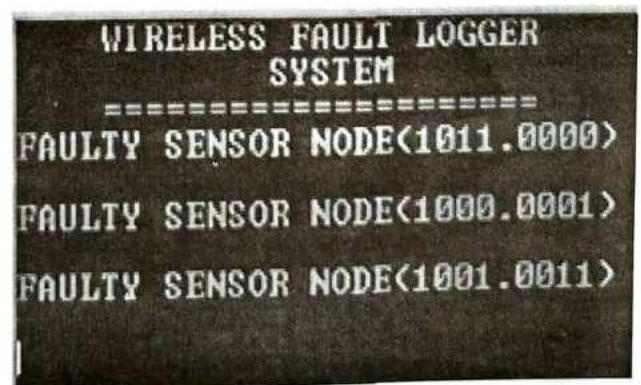


Figure 7: Simulation Result of Sensor node and fault detection using sensor address

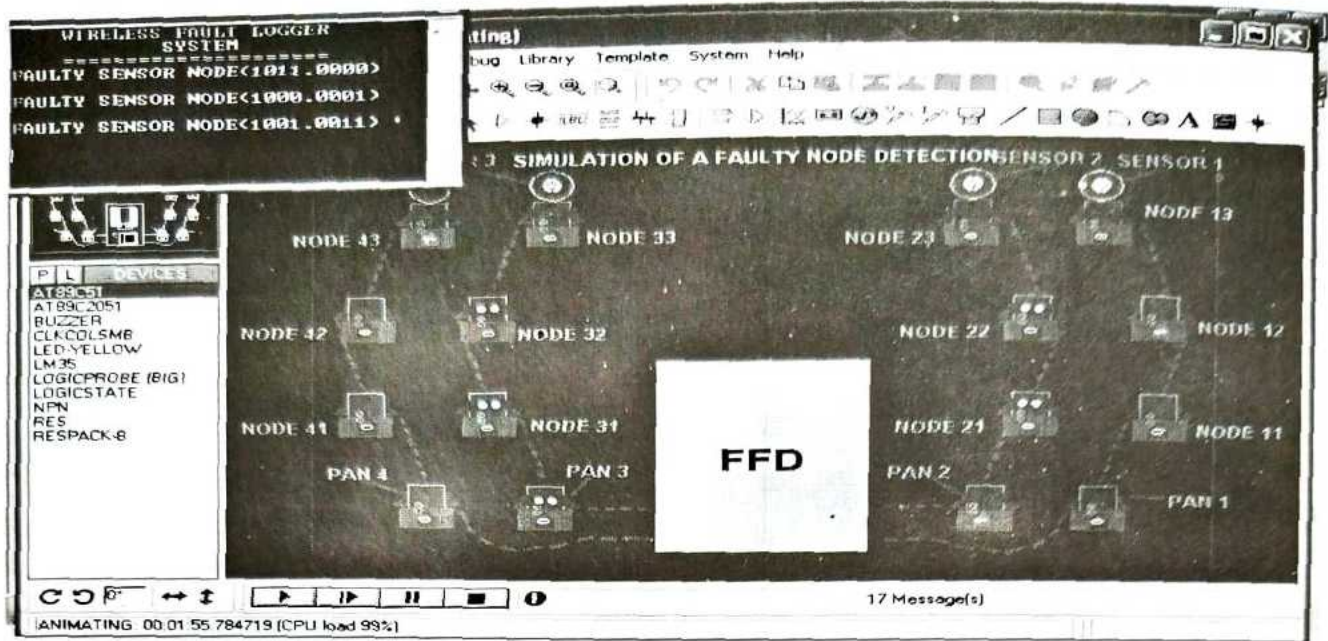


Figure 8: Routine implementation using Proteus Laboratory

Figures 7 and 8 was used to demonstrate how the entire process works, the PROTEUS Software window was used to realise data transmission with the aid of the node addressing technique earlier mentioned, FFD is the sink where the PAN heads reside, which is the final destination of all the nodes in the particular PAN network.

Figure 7 in an additional interface built to local nodes that are faulty with the aid of their respective addresses.

Simulation results in figure 7 show the system can clearly identify the sensors with high accuracy with the aid of the node address. A fault was introduced and the faulty node was identified the aid of the same addressing scheme as practically demonstrated in figure 7.

Plate I and II are pictures of demonstration in the testbed as shown in Figures 9 and 10.



Figure 9: PLATE I WSN address test conducted



Figure 10: PLATE II Inter-sensor WSN address test conducted

5.0 Conclusion

This work establishes the fact that an 8 bit processor can manage a maximum of 65,025 addressable sensor nodes. The method also proffer solution to localising faulty node in a wireless sensor Network, as the artificial neural network method will help detect faulty node using node address as shown in Proteus software interface figure 4.1 and 4.2. The paper evolved a method of routing using artificial neural network and Personal Area Network (PAN), by coming up with a sink node head called Full Functional device (FFD) and source node call Reduce Functional device (RFD), it manages its own network within a PAN, which is an array of node arranged in an ordered form to transmit data from one node to another within a particular PAN, it was able to arrange and

organise scattered node in matrix form to transmit data between various PAN within the entire network, this work employs a transmit and receive technique by acknowledging the source and sink addresses respectively, this communication system simply send data when it has data ready to be sent and also receive acknowledgement.

References

- [1] A. K. Somani and V. K. Agarwal, "Distributed Diagnosis Algorithms for Regular Interconnected Structures", IEEE Transaction of Computers, Vol. 41, No. 7: pp 899-906, July 1992.
- [2] M. Ding, D. Chen, K. Xing, and X. Cheng., "Localized Fault-tolerant Event Boundary Detection in Sensor Networks", Proceedings of IEEE INFOCOM 2005, Miami, March 2005.
- [3] Gao, J.L.; Xu, Y.J.; Li, X.W., "Weighted-Median Based Distributed Fault Detection for Wireless Sensor Networks", *J. Softw.* 2007, 18, pp 1208-1217.
- [4] Azzam I. Moustapha, and Rastko R. Selmic, "Wireless Sensor Network Modeling using Modified Recurrent Neural Networks: Application to Fault Detection", IEEE Transactions on Instrumentation and Measurement, Vol. 57, No. 5, May, 2008
- [5] Jonathan Isaac ,Chanin Andrew R. Halloran, "Wireless Sensor Network for Monitoring, Applications", University of Worcester Polytechnic Institute.
- [6] JinranClen, Shubhalher, "Distributed Fault Detection in Wireless Sensor Network", Dependable Computer and Network Lab, University of IOWA
- [7] Zhen Fang*, Zhan Zhao, Xunxue Cui, Daoqu Geng, Yundong Xuan, LiDong Du, Jing Xu, ShaoHua Wu conference proceeding world IET International conference on Wireless Sensor Network 2010 State Key Laboratory of Transducer Technology, Institute of Electronics, Chinese Academy of Sciences, China,
- [8] JamesAgajo, H.C. Inyiama, and A.L. Theophilus, "Remote Monitoring and Estimation of Carbon Monoxide Pollution in Indoor Environment using Wireless Sensor Network via Satellite", The Pacific Journal of Science and Technology, Vol. 12. No. 2. November 2011 (Fall),<http://www.akamaiuniversity.us/PJST.htm>