International Conference on Electrical Engineering, Informatics, and Its Education 2015

Fuzzy Shortest Path for Solving Link Failure Problem in Body Area Network

Aripriharta, Gwo-Jia Jong
Institute of Electronic Engineering
National Kaohsiung University of Applied Sciences
Kaohsiung, Taiwan
aripriharta@gmail.com

***Abstract*—During crowded situation, link failure is the most common problem in body area wireless network (BWSN). Even the nodes still alive, the communication path between nodes is probably blocked. In order to maintain the data transfers, path planning algorithm must be well considered. In this paper, we proposed an alternative path planning algorithm based on Fuzzy by utilized signal strength (RSSI) and link quality (LQI) from sensor nodes. Then, we compared our algorithm with the traditional path planning and ant colony algorithm. Based on the simulation, our algorithm is better than the others.**

***Keywords*— link failure; fuzzypath planning; BWSN; RSSI; LQI**

I. Introduction

A body area wireless sensor network, or BWSN for short, is deployed with the goal of gathering bio-data or psychological parameters, such as body temperature, blood pressure (BP), heart rate variability (HRV), etc. from several bio-sensor nodes attached to human body, then relay that data to a coordinator or sink via multi-hop. Thus, due to the very important bio-data carried by the nodes, a high-performance path planning for bio-data gathering becomes more and more challenging [1-2].

Recently, the path planning algorithms have been concerned with multi path solutions that repair broken links. There are two main factors that cause broken links in wireless communication, node failureand link failure. The first factor is common and well-studied [4-6], [7], [8], [9]. In contrast, only a few papers [6] considered the second problem. And, especially in the case of bio-data gathering, the possibility of link failures is very high because of the presence of obstacles (e.g., patients, room layout, etc.). Therefore, in this paper, we propose anfuzzy path-planning (FPP) algorithm that repairs link failures.

Our goal is to solve blocked path in BWSN to maintain the bio-information collection. Thus, we provide solution by fuzzy approach and give the following contributions:

how to detect the presence of surrounding nodes and access an unused channel to establish an alternate link, then make the right decision in terms of choosing the appropriate nodes as an optimal path are problems addressed in this paper.

Model of the blocked channel problem that is prone to occur for paired nodes in a wireless communication network for a bio-data monitoring system is performed.

Utilize a variation of RSSI (or power levels), LQI and the channel status as the input parameters for path planning and solve it using a fuzzy approach.

The rest of the paper is organized as follows. Section 2 shows the problem formulation. In Section 3, we present the Fuzzy path planning algorithm methods and its ability to avoid blocked links. We demonstrate our simulation and present the results in Section 4. Finally, we conclude this paper in Section 7.

II. Problem Formulation

As shown in Figure 1, the network gathers bio-data from Edn through the path R1→ R2→Edn. Consider if, in area 1, an object covers the line of sight of the radio communication between Edn and R3 and breaks the link, such that the data gathering process fails. In this situation, we borrow the cognitive radio theory [5]; we can consider this event as a temporal or spatial spectrum access in the sub network.

Due to its ability to calculate results quickly and precisely, fuzzy logic is an appropriate approach for routing in WSNs, which require simple and fast methods to make decisions. Moreover, fuzzy logic needs only low computation resources and human nature to define its parameters, making it a suitable method for routing decisions in WSNs. Fuzzy logic is similar to human-thought logic and provides a simple method to conclude the imprecise, vague, or ambiguous from input. Furthermore, fuzzy logic is a simple method because it uses human language for inputs and outputs. The calculations are performed by an inference engine (or FIS), namely Mamdani or Sugeno, which are widely used in fuzzy-logic-based systems [9]. The above FISs proceed in four phases, fuzzyfication, rule evaluation, combination or aggregation of rules, and defuzzyfication. There is no large difference between them, so we used Mamdani [4] in this paper.

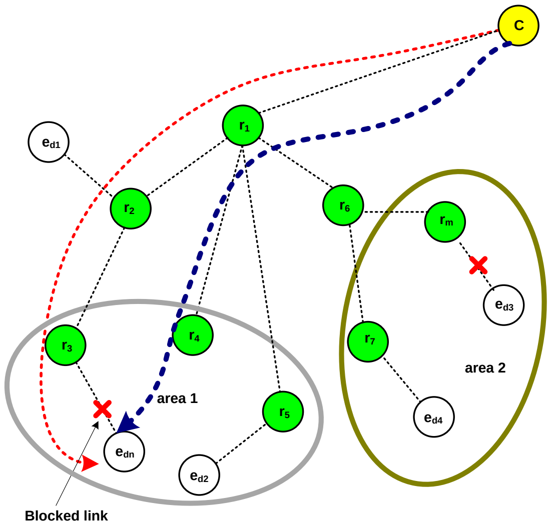

Fig. 1. Link Failure in a BWSN System

III. METHODS

Initially, the nodes will store the RSSI values from all neighbors, then create matrix R, matrix M and matrix Q. Then, the adaptive path selection process is utilized. In this step, each link will evaluate using the fuzzy knowledge base. The old path (the dotted red line) was the initial path for data gathering from C→R1→R2→R3→Edn in area 1 in Fig. 5. When the link between R3 and Edn is blocked, the fuzzy processing solves this by checking all of the available channels (e.g., R4 and R5) according to the RSSI and LQI and then choosing another by giving the privilege to router R4 as a slave that has the right to use the channel. R3 finds the new path (the dotted blue line) through the 'master' R3 to reach Edn. Therefore, the new path is C→R1→R2→R3→R4→Edn. It is also the same condition for area 2; while the slave Rm→Ed3 is blocked, a new path will be calculated by our algorithm to give the optimal solution.

The block diagram of the proposed FPP system is shown in Fig 2. The source node's carried bio-data are set as the input of this algorithm, and the output is the destination node through multiple hops. The core of the FPP algorithm is the optimal path selection, which uses a fuzzy method. The fuzzy system uses three input variables, the RSSI {low, medium, high}, LQI {weak, medium, strong}, and MMSE {low, medium, high}, which are drawn in a triangular fuzzy membership function.

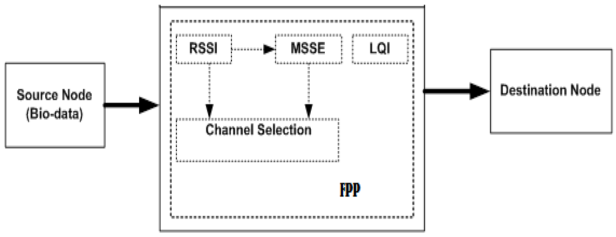

Fig. 2. The proposed FPP algorithm

IV. RESULTS AND ANALYSIS

As shown in Fig. 3, the FPP path selection mechanism we proposed is superior to the traditional model. The traditional model is a random path selection mechanism, such as opportunism; when it feels the next node will have the opportunity to send data, it selects the node. As shown in Fig. 4, through a larger number of nodes and the fuzzy knowledge mechanism, our method can effectively reduce the congestion rate of data transfers. This adaptive method can also avoid long waiting times caused by packet loss problems, as shown in Fig. 5, and achieve optimal path planning.

A stag communication (R3→Edn) can be seen as a master, while the adjacent active communication path (e.g., R3→Ed3) is seen as a slave. Thus, end devices Edn should be reached by the router r3, which in this case has the role of master. If any of the channels have been opened, then the chosen master will open the communication channel for the slave to access the bio-data from the end devices Edn and relay it to the next routers r1. This process is creating a new path for transferring bio-data from edn, and this path is R1→R2→Edn.

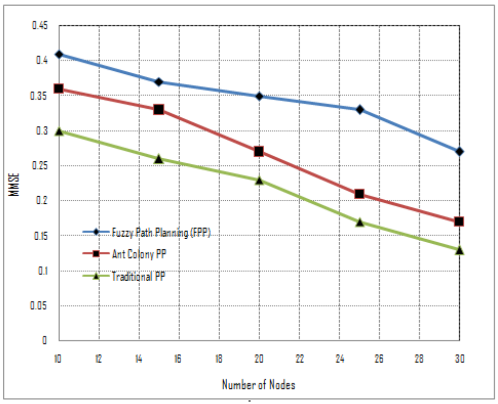

Fig. 3. MMSE of the path selection mechanism

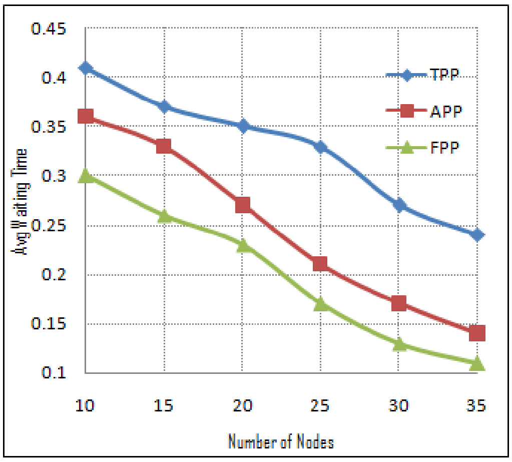

Fig. 4. Average waiting time of data transfer

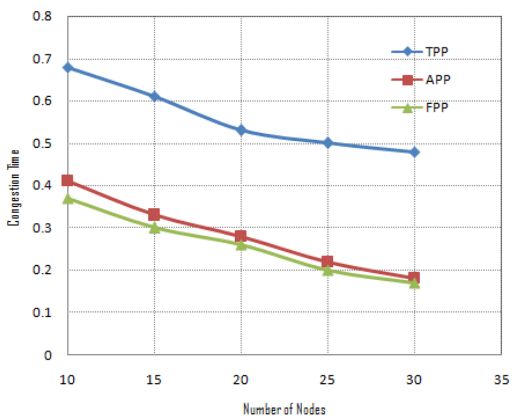

Fig. 5. Congestion rate of data transfer

V. CONCLUSION

In this paper, Fuzzy path planning for body area wireless sensor networks is presented. Our proposed fuzzy path selection mechanism could effectively reduce congestion rates of data transfers, avoid long waiting times caused by packet loss problems and achieve optimal path planning of objects compared with the traditional path planning algorithm that uses a random selection method to find the next nodes.

ACKNOWLEDGEMENT

This work was supported by DIKTI scholarships 2014 under contract Number: 124.67/E4.4/2014 date: July 7th, 2014

REFERENCES

[1] G-J. Jong, C-S. Huang ,G-J. Yu , and G-J. Horng. Artificial Neural Network Expert System for Integrated Heart Rate Variability , Wireless Persona Communication pp. 483-510.2013.

[2] S. Zhang; T. Wu, and V.K.N. Lau, "A low-overhead energy detection based cooperative sensing protocol for cognitive radio systems," Wireless Communications, IEEE Transactions on , vol.8, no.11, pp.5575,5581, November 2009

[3] J. Ma; G.Y. Li, B-H Juang, "Signal Processing in Cognitive Radio," Proceedings of the IEEE , vol.97, no.5, pp.805,823, May 2009

[4] A.M. Ortiz; F. Royo; T. Olivares; J.C. Castillo; L. Orozco-Barbosa, and P.J. Marron,"Fuzzy-logic based routing for dense wireless sensor networks", Telecommunication System. Volume 52, Issue 4, pp 2687-2697, April 2013

[5] A.E. Zonouz, L. Xing, V.M. Vokkarane, and YL. Sun, "Reliability-Oriented Single-Path Routing Protocols in Wireless Sensor Networks," Sensors Journal, IEEE , vol.14, no.11, pp.4059,4068, Nov. 2014

[6] G. Egeland and P.E. Engelstad, , "The availability and reliability of wireless multi-hop networks with stochastic link failures," Selected Areas in Communications, IEEE Journal on , vol.27, no.7, pp.1132,1146, September 2009

[7] J. Shin; C. Sun, "CREEC: Chain routing with even energy consumption," Communications and Networks, Journal of , vol.13, no.1, pp.17,25, Feb. 2011

[8] A.A. Abbasi, M.F. Younis, and U.A. Baroudi, "Recovering From a Node Failure in Wireless Sensor-Actor Networks With Minimal Topology Changes,"Vehicular Technology, IEEE Transactions on , vol.62, no.1, pp.256,271, Jan. 2013

[9] W. Huang; L. Ding, "The Shortest Path Problem on a Fuzzy Time-Dependent Network," Communications, IEEE Transactions on , vol.60, no.11, pp.3376,3385, November 2012