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Introducing a Routing Protocol Based on Fuzzy Logic in Wireless Sensor Networks

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ABSTRACT

Although routing is one of the key network issues, the challenges facing WSN makes the subject even more demanding. In this study, we propose a routing protocol in wireless sensor networks using fuzzy logic. .In the other words, when a node contains data to send, the fuzzy logic determines the next hop which the sensed data must be sent.

KEYWORDS: Wireless Sensor Networks , Routing , Fuzzy Logic.

1. INTRODUCTION

The latest advances of Electronics technology and energy use reduction of electronic devices lead to the devices being equipped with small sensors with lower power consumption. These sensors sense their surroundings and convert data to an electric signal. Routing in wireless sensor networks embraces a different concept comparing to other wireless communication networks due to a handful of fundamental characteristics; therefore, the researchers have faced new challenges. The very first challenge in wireless sensor networks is incapability of building a unique global address for each node. Consequently, the protocols, used in those wireless networks functioning under IP protocol, will be considered useless in such networks. The second challenge is that nearly all applications under WSN require transferring the sensed data from the surroundings to a certain unit, called the base station. As for the third challenge, the data traffic generated in these networks has a considerable redundancy. One event can be detected by different nodes and they accordingly send the same data. Such redundancies should be considered in order to use energy consumption in nodes and bandwidth more logically. The fourth challenges concern the limitations in data-saving energy, power computation, and node total capacity[1].

2. Review of Literature

Fuzzy logic is used to recognize the values which are not one hundred percent true or false, and which are facing against classical logic that has been utilized in control systems thus, they are widely used in various systems, such as WSNs to name a few. Algorithm of [2] introduces a routing protocol which by using fuzzy logic obtains the node's residual energy, local density inside its sensed region, and time as input parameters of fuzzy module. This leads to a fair distribution in order to make a cluster. This protocol benefits from two fuzzy modules.

Algorithm of [3] presents a routing protocol which selects the proper cluster head based on fuzzy logic. Selecting the proper cluster head has an impact on energy saving and extending the network lifetime.

By using three parameters of energy, density and centricity this algorithm makes better decisions of fuzzy modules. In algorithm of [4], the head clusters are selected by the base station. Fuzzy controller is the most important component of their routing protocol. Its input parameters are the head cluster's center of gravity , node's remaining energy, and the network traffic. In [5] the extended regions by nodes are divided into two main parts based on their distance to the base station.

3. Problem Definition and Solving

In this study, we propose a routing protocol for WSN whose operation is based on fuzzy logic. Through designing, we assume that the network architecture and operation are flat and query-based accordingly. Besides being proactive, routing happens at the time of generating sensed data.

4. Designing Routing Based On Fuzzy Logic

The first step to solve the early problem, the fuzzy module is designed based on the Mamdani fuzzy inference system (FIS). In Mamdani system, input and output are expressed in fuzzy. Figure 1 illustrates parts of a fuzzy system.

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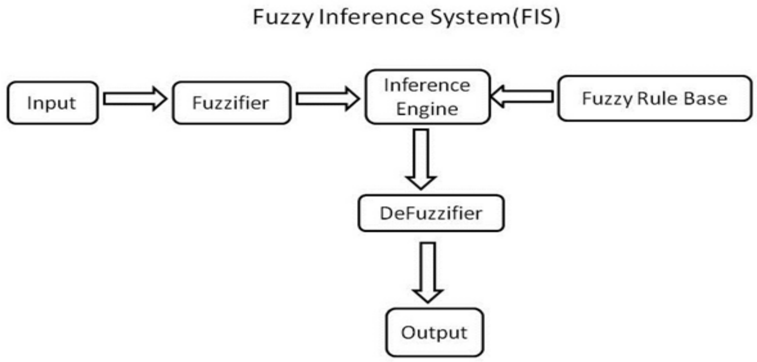

Fig 1. Fuzzy inference system components

Five parameters Residual energy of node, path traffic, numbers of hops to the base station, packet priorities and received signal strength indicator (RSSI) are input parameters of the fuzzy module. These parameters enter the fuzzy module through neighbour management unit (NMU).Figure 2 illustrates our proposed routing mechanism.

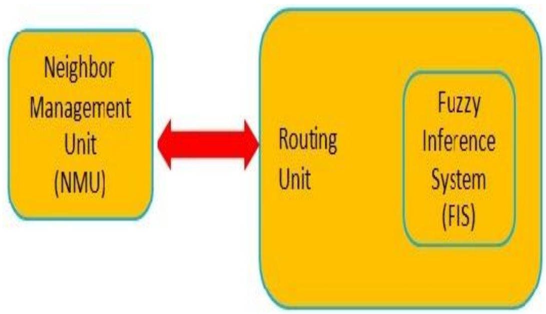

Fig 2. Proposed routing mechanism

Figure 3 illustrates the function membership related to the node's residual energy. Table 1 illustrates the information concerning the other membership functions of fuzzy module.

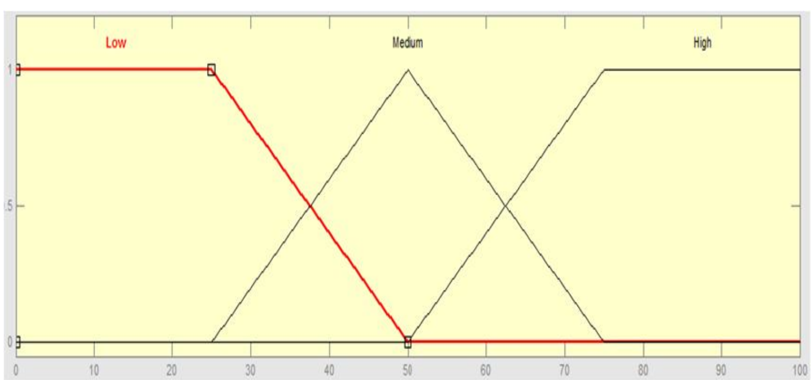

Fig 2. Residual energy membership function

According to figure 1, the fuzzy rules are used as one of fuzzy system parts. The following is the general idea of a fuzzy rule:

IF Variable Is Set Then Action

Since we have used the Mamdani FIS in routing designing, to receive satisfying output, we utilize center-of-gravity function in order to dismiss the output from its fuzzy mode. When a node contains sensed data, the NMU provides the requiring information for the fuzzy routing module. The output parameter is considered to be as the node goodness. Thus, the fuzzy inference engine calculates the node goodness value and singles out the most suitable node.

Table 1. Fuzzy module membership function

	Low	Medium	High
Path Traffic(%)	0 < <40	30 < < 80	70 < < 100
Number Of Hops	0 < < 3	2 < < 4	3 < <5
Packet Priority	0 < < 1	0.5 < < 1.5	1.5 < < 2
RSSI(%)	0 < < 50	50 < < 75	50 < < 100
Node Goodness	0 < < 0.5	0.25 < < 0.75	0.6 < < 1

5. Reviewing Of Simulation Results

Having done the simulation in Matlab simulator. Simulation results illustrate in figures 4-8. In figure 4 illustrates the input parameter ratio of residual energy with packet priorities for determining node goodness to select the next hop. According to the figure, when energy is low, the goodness value of node is low for any packet with any priority. With increasing of residual energy, the goodness value of node increases and for packets with high priority the goodness value reaches to the highest point.

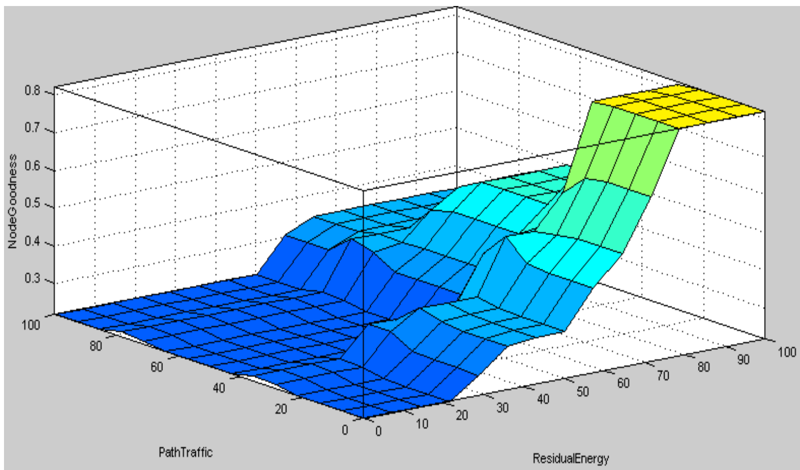

Fig 4. Residual energy and packet priority

In figure 5 illustrates the path traffic ratio with hop count for determining node goodness. When the path traffic is light and node count is low, the goodness value of node reaches to its highest point. With increasing of the path traffic, the goodness value decreases. For that node whose hop count is high to the destination and its traffic is heavy, the goodness value of node, comparing to the other nodes, reaches to the lowest point.

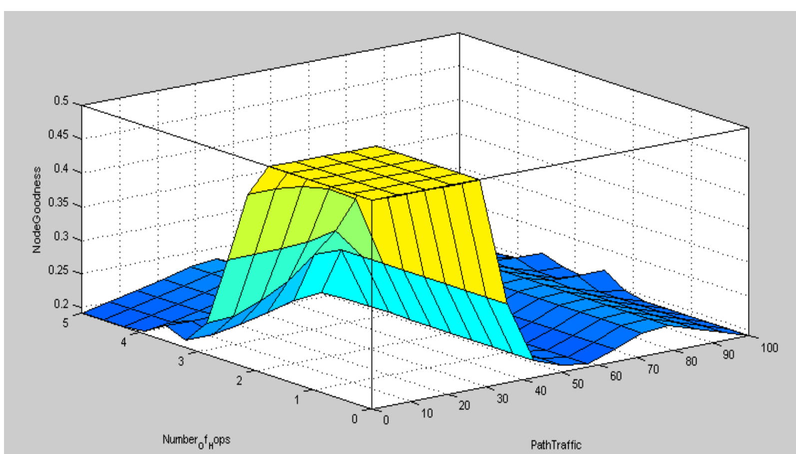

Fig 5. Path traffic and number of hops

In figure 6 illustrates the residual energy ratio with path traffic for determining node goodness to choose the next hop. For the node having low residual energy with any level of traffic, the node goodness value of that node is low. The goodness value of node increases, when the residual energy of node increases and the traffic level reduces. For that node with high residual energy which benefits from a light traffic level, the goodness value reaches to the highest possible point.

In figure 7 illustrates the parameter ratio of packet priorities with the path traffic for determining the goodness value of node. When the path traffic of a node is low, the goodness value of node is high for any level of packet priority. With increasing of traffic scale, the goodness value of that node is good enough only for packets with high priority.

In figure 8 illustrates parameter ratio of received signal strength indicator from the node with path traffic for determining the next hop. When path traffic is low, the nodes with received signal strength indicator have node goodness where this ratio for high received signal strength indicator reaches to the highest possible point.

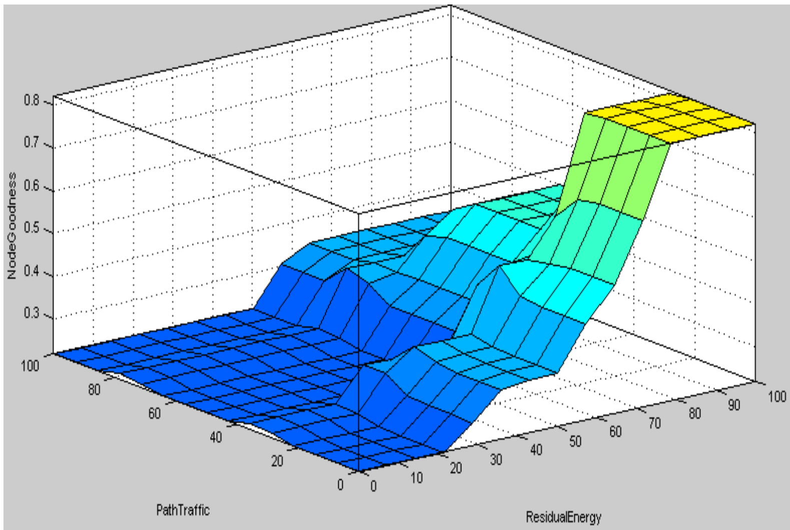

Fig 6. Residual energy and path traffic

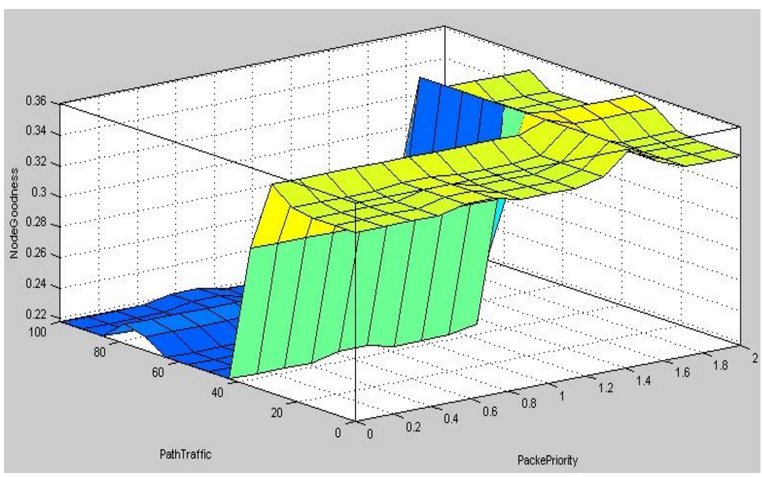

Fig 7. Packet priority and path traffic

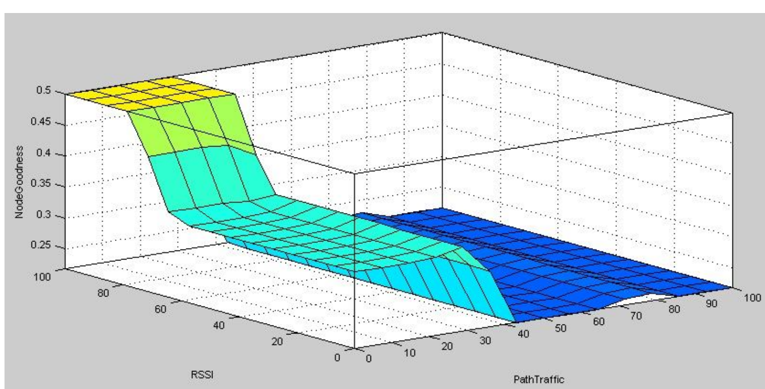

Fig 8. Path traffic and RSSI

Conclusion

In this study, fuzzy logic has been used to determine the next node in order to transmit sensed data to the base station. As it has been already mentioned in Simulation Results section, energy of node is considered to be as a more important parameter to determine the next node in routing operations. Moreover, parameters number of hop , packet priorities, path traffic, received signal strength indicator are ordered based on their importance. In the proposed routing, providing service quality for those applications which require special service quality has not been considered. To improve the routing accuracy, resolution of the membership functions can be increased for each input parameter. These issues can be topic of other studies to improve routing.

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