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IDENTIFICATION OF EFFICIENT WIRELESS SENSOR NETWORK USING FUZZY LOGIC METHOD

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ABSTRACT

A wireless sensor network (WSN) consists of sensor nodes and base stations which are connected via wireless medium. A key functionality of WSNs consists in collecting information from sensor nodes & transporting the information of interest to the base stations required by the applications. Wireless connectivity, size and low cost of sensors in WSNs are its advantages which enable it to be deployed in hostile or inaccessible environments at a very low cost. However, WSNs suffer from high data loss due to error prone wireless transmission medium, transmission problems in hostile environments and node failures due to limited energy of sensor nodes. Hence reliable data transportation i.e. ensuring data delivery with minimum loss becomes the key issue in WSNs.

Keywords: communication protocol, congestion, energy efficiency, Wireless Sensor Network.

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1. INTRODUCTION

The Wireless Sensor Network is a wide emerging area for research in the field of networking and is thus producing interest because of the wide variety of applications. A Wireless Sensor network is defined as a collection of sensor nodes and sink nodes which are been connected through wireless communication network[1].

For assurance of reliability of data delivery between the sensor node which can deliver their sensed data to the sink. Assuring reliable data delivery between the sensor node and sink in Wireless Sensor Network is a challenging task as WSN suffer from data loss which is high and due to the weakness of wireless transmission medium , environmental interference node failure and battery depletion .

The wireless sensor network are the composition device which uses sensor nodes. They are ad-hoc in nature and are used to monitor physical and environmental conditions at different locations. Due to the rapid evolution of wireless technology and significant growth of wireless sensor services. Within the framework of Wireless Sensor Network there is a lot of potential which can be used to support a large number of applications.

2. FEATURES OF WSN

The Wireless Sensor Network can thus be described as a source sink architecture which may include any number of source node to generate data which is usually by using sensors for measuring environmental factors such as temperature, humidity or radiation, sink nodes for collecting data gathered from source nodes and the relay nodes which aids the transmission from source to sink[4].

The inherent feature of node redundancy is helpful in increasing the fault tolerance but reliability level of the system may or may be achieved. The methodology for modelling the reliability of data transport is to be determined. In WSN during data aggregation there is loss of information which occur frequently because of faults like random link failure and hazard node fault but it have limited resource. The node failure alerts the topology of network which results in segmented routing path as well as loss in message information which causes reduction in the reliability of the system.

WSN are application driven and are used in various different applications which have different requirement and leads to different network architecture and protocol . It is easy to use as it is not necessary to always deploy some access points in advance due to the fact that the sensors can organize automatically into the network. Depending upon the area of application of WSN they can have as large as thousands of sensor nodes so one of its key feature is its large sale application. : In the cases where the sensor network are self organized there the network does not need to be configured in advance as the sensor node can be organized when I is deployed so it may not require human interaction for deployment in the network. They generally posses one or multiple sink nodes and in this mesh network the traffic can be from any node to any other node. There is les mobility of node in this sensor network as they are majority used in event tracking purpose. Since this network consist of several nodes which communicate with each other which have several paths so packet transverse from one node to another so multi hop feature can be conserved in this system. : In WSN the nodes are distributed in wide geographical area with a large number of nodes so the size of the network is large. In this system the data is requested depending upon physical quantities of the network hence it is data centric and node is aware of its relative position with respect to the other node by knowing their real location. And the data is collected according to that position.

In wireless sensors, if one node fails then it does not affect the network operation because there are other adjacent nodes collecting similar data. The accuracy of data collected is reduced and to have a proper request-response model the node should request to a proper node and this node should process the request efficiently and reply as soon as possible.

3. CHALLENGES IN WIRELESS SENSOR NETWORK

Challenges in wireless sensor network arise in implementation of several services. There are so many controllable and uncontrollable parameter by which the implementation of wireless sensor network affected such as Energy Conservation, Operating Environment, Communication, Availability of Resource, Data Processing, Scalability and Node Id.

The characteristics of sensor networks and requirements of different applications have a decisive impact on the network design objectives and challenges in terms of network capabilities and performance. Sensor nodes are small-scale devices with volumes approaching a cubic milli-meter in the near future[9,11]. Such small devices are very limited in the amount of energy they can store or harvest from the environment. Furthermore, nodes are subject to failures due to depleted batteries or, more generally, due to environmental influences. Limited size and energy also typically means restricted resources (CPU performance, memory, wireless communication bandwidth and range).

In each of the network protocol, energy efficiency and network reliability are key aspects of developing protocols for WSN. Due to the limited power available in sensor nodes for data collection and communication, conserving energy is paramount in extending network life. Eventually, energy resources are depleted leaving the network to manage continued performance in the presence of failed or failing nodes. This in conjunction with the inherent unreliability of wireless communications has endeavoured the research community to cultivate FT mechanisms to improve the probability of successful operation and reduce the inefficiencies in lost or corrupted traffic.

Energy efficient techniques play a significant role in saving the energy. One of the techniques is the topology control mechanism. There are many existing Topology control protocols, each one is having its own advantages as well as disadvantages. After looking through this existing protocol, and decide to the protocol which reduces the total energy consumption in the network and thus maximize the life time of the network.

4. MEMBERSHIP FUNCTION FOR FUZZY LOGIC

In the proposed Wireless Sensor Network reliability model, the inputs are protocol which are proved to be the most effective of all types in the Wireless Sensor network and are five in number so we consider a parameter which ranges from 1 to 8 where 1 stands for ERST protocol, 2 stands for CODA protocol, 3 stands for Fusion protocol, 4 stands for PORT protocol, 5 stands for RCRT protocol, 6 stands for CCF protocol and 7 stands for SMAC protocol. The second input is Congestion mitigation which has inputs which includes AIMD like end to end rate adjustment give a value of 30, Hop by hop rate adjustment with value 60, Multipath routing with value 80 exact hop by hop rate adjustment with a value 100. The third input is queue size with input level as 5 smallest queue, 10 for small queue level 15 for medium queue level and 20 for high queue level. After that, the membership functions are constructed.

The membership function is of trapezoidal or triangular function and the main input parameters are:

A. Protocol

This is one of the fuzzy input whose value ranges from 1 to 7 where the range of 1to1.8 is for ERST protocol, 1.8 to 2.2 ranges for CODA protocol, 2.2 to 3.2 is for Fusion protocol 3.2 to 4.2 for PORT protocol, 4.2 to 5.2 for RCRT protocol; ,5.2 to 6.2 for CCF protocol and 6.2 to 7.0 for SMAC protocol. All the input values of protocol method usage are fuzzified using the membership function in the range of 1to 7. It is used to maximize the amount of power utilization, so for rule generation, a higher power will get more priority.

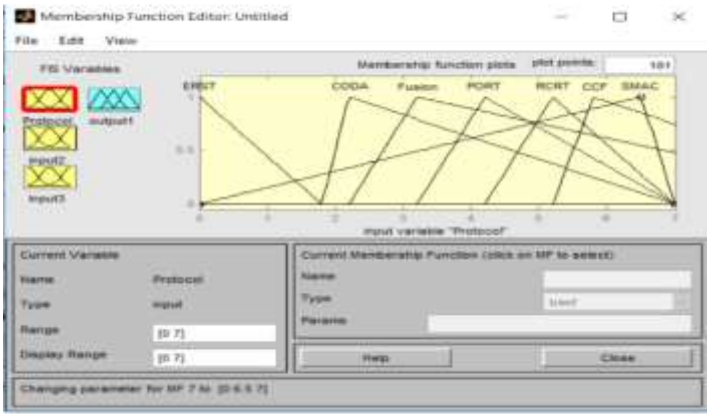

Figure 1 Membership function for input of Communication Protocol

B.Congestion Mitigations

This is one of the fuzzy input values which ranges from 1 to 100 where 1 to 30 is the range when the mitigation method is AIMD like end to end rate adjustment, 25 to 60 is for Hop by hop rate adjustment and 57 to 80 is for multipath routing and 78 to 100 is for exact hop by hop rate adjustment.

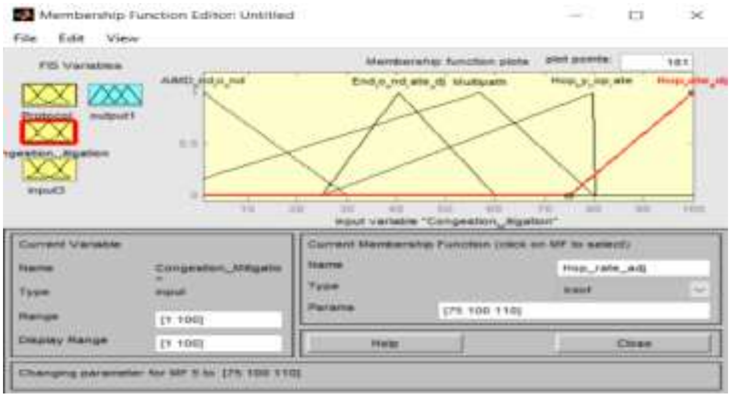

Figure 2 Membership function for input of Congestion Mitigation

C.Queue

This is one of the fuzzy input whose value ranges from 1 to 7 where the range of 1to 5 ranges for the system which are very small so the que is very small due to lesser number of nodes available , 4.5 to 10 is the range for small queue system, 8.9 to 15 is the range for medium queue in the system and 14.7 to 20 is the range for high queue system.

Figure 3 Membership function for input of Queue in WSN

D.Energy Effeciency

This is the output of the system which is used to identify that a system is energy efficient or not and how does the energy efficiency changes with the change in selection of mitigation method and the communication protocol according to the size of the system. The efficiency improvement factor is defined in the output which is defined as very small, small, moderate, average, large, and Very Large. The range of the output lies between 1 to 80. The very small value starts at 0 and goes to 35; beginning at 32, it starts to overlap with small and it ranges up to 55.From the 52 it start to overlap with moderate time which ranges from 52 to 70. At the beginning of 68 it starts to overlap with average value. Similarly, the large efficiency starts at 71 and overlaps with Very high at 75. After 73, all the values are considered very large efficiency.

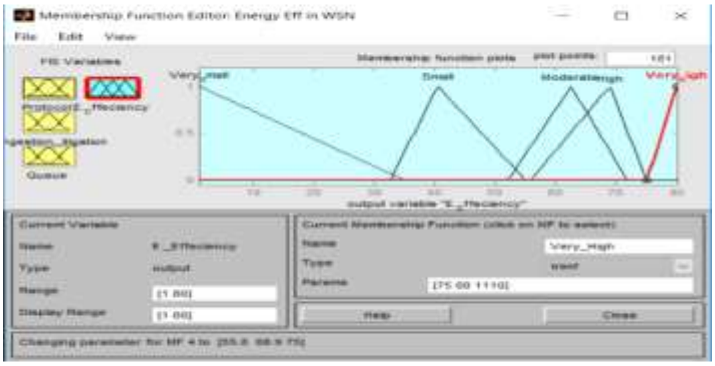

Figure 4 Member function of Output which is Energy efficiency

5. RULE BASE FOR FUZZY LOGIC SYSTEM

Fuzzy rules are linguistic IF-THEN- constructions that have the general form "IF A THEN B" where A and B are (collections of) propositions containing linguistic variables. A is called the premise and B is the consequence of the rule. In effect, the use of linguistic variables and fuzzy IF-THEN- rules exploits the tolerance for imprecision and uncertainty. In this respect, fuzzy logic mimics the crucial ability of the human mind to summarize data and focus on decision-relevant information.

To successfully design an energy efficient system for Wireless Sensor Network using fuzzy logic an understanding of the basic components of a fuzzy decision system is important. These include fuzzy logic concepts such as fuzzy sets and their properties, fuzzy rule base, and fuzzy inference system.

The algorithm design for fuzzy based inference system which act as a controller is as shown in the diagram

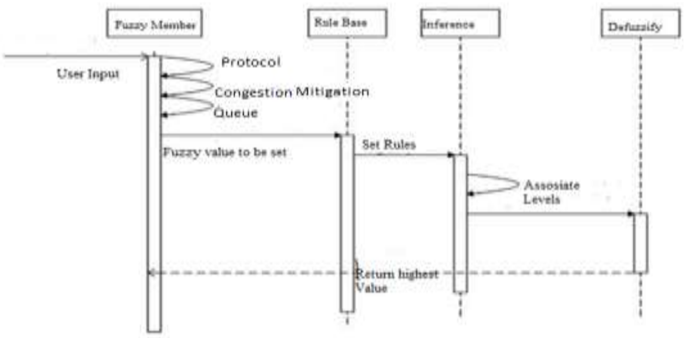

Figure 5 Flow Diagram of Fuzzy Based Control

The system model is to be performed using the Matlab/Simulink software version 7.7. Simulink is an environment for multi domain simulation and model-based design for dynamic and embedded systems.

It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement and test a variety of time-varying systems including power, communications, controls, signal processing.

The rule base for Energy efficiency of wireless sensor network is as shown in the table 1 below

Table 1 Fuzzy Logic Rule Base for Clearance time of Fault

S.	Protocol	Congestio Mitigation	Queue	Energy Efficient
1	ERST	AIMD end to end	Very small	Very Small
2	ERST	End to end rate adj	Small	Very Small
3	ERST	Multipath	Medium	Small
4	ERST	Hop by hop rate	Large	Small
5	ERST	Hop rate adj	Very small	Large
6	CODA	AIMD end to end	Small	Small
7	CODA	End to end rate adj	Medium	Medium
8	CODA	Multipath	Large	Medium
9	CODA	Hop by hop rate	Very small	Small
10	CODA	Hop rate adj	Small	Medium
11	FUSION	AIMD end to end	Medium	Medium
12	FUSION	End to end rate adj	Large	Very Small
13	FUSION	Multipath	Very small	Very Large
14	FUSION	Hop by hop rate	Small	Medium
15	FUSION	Hop rate adj	Medium	Large
16	PORT	AIMD end to end	Large	Very small
17	PORT	End to end rate adj	Very small	Large
18	PORT	Multipath	Small	Very Large
19	PORT	Hop rate adj	Medium	Medium
20	PORT	Hop by hop rate	Large	Medium
21	RCRT	AIMD end to end	Very small	Large
22	RCRT	End to end rate adj	Small	Large
23	RCRT	Multipath	Medium	Very Large
24	RCRT	Hop by hop rate	Large	Medium
25	RCRT	Hop rate adj	Very small	Large
26	CCF	AIMD end to end	Small	Large
27	CCF	End to end rate adj	Medium	Small
28	CCF	Multipath	Large	Medium
29	CCF	Hop by hop rate	Very small	Very Large
30	CCF	Hop rate adj	Small	Very Large
31	SMAC	AIMD end to end	Medium	Medium
32	SMAC	End to end rate adj	Large	Large
33	SMAC	Multipath	Very small	Very Large
34	SMAC	Hop by hop rate	Small	Very Large
35	SMAC	Hop rate adj	Medium	Very Large

The fuzzy logic controller uses three fuzzy inputs which are Fault current Index, distance location of the fault and the price of the electricity prevailing in that faulty line which depends on the fixed tariff of the country and the sector to which it provides the supply.

6. RESULT & CONCLUSION

A fuzzy logic base system is designed on the basic of observed types of protocol over different type of communication system in the wireless Sensor Network . The different types of communication protocol is been considered for which the mitigation techniques are been used to reduction the congestion in data transmission depending upon the type of the system i.e. the presence of number of nodes of the wireless sensor network ,and based on these collected data here a proposed model is constructed which will define the energy efficiency of the wireless sensor network. The result can thus display the priority of energy efficient system when selected on the basis of protocol of communication and mitigation of congestion with respect to the size of the wireless sensor network. From the fuzzy model we observed that when the protocol is PORT and we use Multipath mitigation technique for reduction of congestion on a system with large number of node which have large queue the energy efficiency is around 62 percent as shown in the figure 6 below:

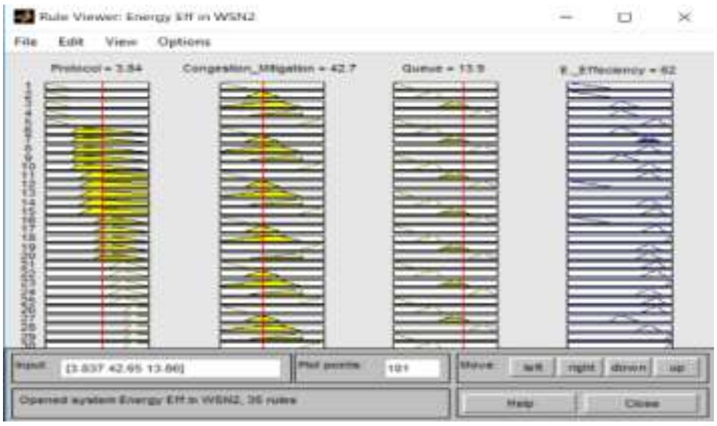

Figure 6 Fuzzy Logic with Parameters

The energy efficiency of the system is prioritized with the help of a fuzzy model which gives us the information about the percentage of the energy efficiency when a particular protocol is used along with the mitigation technique and queue scheme of the system.

These protocols has proved efficiently that they are more useful in not only routing the most important data but also in conserving energy resources of a sensor (the batter) using different operation approaches. A detail study of routing of a few protocols is carried in this thesis which focused on the energy conserving schemes used by protocols. This has a large scope when this system is been realized for their real time support towards application like surveillance.

There is also scope of study of the design trade off between energy conserving and quality of service support, results when protocols are tested on the assumption factors like latency, scalability, energy awareness, synchronization, etc. necessary or a wireless sensor network. Contention-based protocols like SMAC, TMAC and TEEM, they use a single radio and change the radio state periodically in order to make the nodes energy efficient. STEM is also a contention-based protocol, but uses two radios (data and wake-up radio) to make the nodes energy efficient

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