Enhancing the Network Lifetime of WSN Using DEFL Hierarchical Algorithm

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Abstract: **Energy consumption of sensor nodes is a key factor affecting the lifetime of wireless sensor networks (WSNs). Prolonging network lifetime not only requires energy efficient operation, but also even dissipation of energy among sensor nodes. On the other hand, spatial and temporal variations in sensor activities create energy imbalance across the network. In this paper, we propose a Distributed Energy-aware Fuzzy Logic based routing algorithm (DEFL) that simultaneously addresses energy efficiency and energy balancing. Simulation results demonstrate that the network lifetime achieved by DEFL exceeds the best of all tested solutions under various traffic load conditions. We further numerically compute the upper bound performance and show that DEFL performs near the upper bound.**

Keywords**: Wireless Sensor Networks (WSN), Fuzzy Logic Algorithm, Energy Efficiency, Traffic Load.**

I. INTRODUCTION

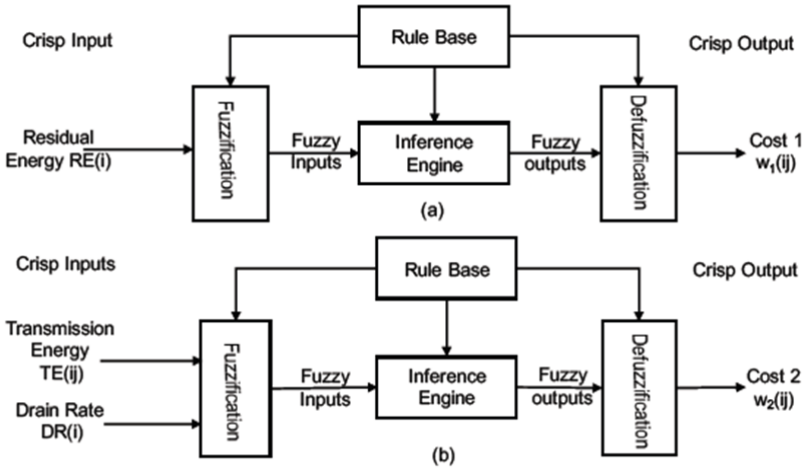
Wireless sensor network (WSN) is a self-configured network of small sensor nodes communicating among themselves using radio signals, and developed in such a way that it can sense, monitor and understand the physical world. The nodes which are present in WSN are called motes. A mote is a node but a node is not always a node. Mote is capable of performing some processing, gathering the sensory information and communication with other connected nodes in the network.

From past researches it is observed that, a major challenge for WSNs lies in the nodes energy constraints. The energy source for sensor nodes is typically a battery. It is widely accepted that when battery runs out of life the usefulness of a wireless sensors expires. Some of the issues like power constraints, limited computing capacity, open environment, Radio connectivity makes the sensor nodes faulty many times. Once the network formed nodes start sensing the information and by using the battery continuously makes battery power down. All the nodes which sense the information will be forwarded it to the nearer nodes and those nodes forward it to the base station. Which makes the network inefficient because all nodes using the power and giving it to the base station. And there is more chance of getting data redundancy by getting the same data from all nodes to the base station even this can make the network inefficient.

The main contributions are given in two ways those are

- A generic formulation of the maximum network lifetime routing problem has been provided. A minimax optimization function, based on Matlab fminimax solver, is used to determine the upper bound lifetime performance of a given network configuration which we use as a performance benchmark.

- A generic framework for designing energy-related cost functions is introduced. Based on the framework, a heuristic routing algorithm DEFL is proposed which combines cost function based routing and fuzzy logic approach to improve network lifetime at different network conditions. Appropriate energy metrics are combined using two fuzzy logic systems which apply soft human logic to blend different metrics. The performance of the proposed algorithm is done through simulation and compared with existing algorithms MTE, FA and MDR, as well as the upper bound calculated by the solver.



(a) Fuzzy System 1 (FS1) deals with the energy level related input. It takes the normalized residual energy or RE(i) of node i. It produces output variable RP1(ij), such that w1(ij) = 1/RP1(ij) .

(b) Fuzzy System 2 (FS2) deals with the energy consumption rate related inputs. It takes two inputs including the transmission energy TE(ij) consumed by node i to transmit to node j and the energy drain rate DR(i) of node i. It produces output variable RP2(ij), such that w2(ij)= 1/RP2(ij).

II. RELATED WORK

A. Related works

Accessibility The election of different routing protocol for efficient communication and survivability of the network is done using Distributed Fuzzy Logic Based Routing Protocol for WSN proposed by[1] with the aim of studying about different routing protocol exists for wireless sensor network. For example, flat based routing where all nodes have the same role and hierarchical routing where nodes have different roles. So when it comes to efficient communication and survivability of the network, hierarchical or cluster based routing is best choice. Now in this paper, they are trying to deal with clustering process in routing protocol using fuzzy logic module and proposed algorithm is implemented on a LEACH protocol. They aim not to minimize the energy consumption of the network but to optimize it and trying to make sure the alive data are still able to forward data to the base station and a proposed protocol are compared to standard LEACH protocol.

The proposed routing technique uses a self adaptive scheme based on a fuzzy control algorithm and aims to increase the network life time by enhancing the LEACH clustering process. The network incorporates two types of nodes. One is cluster heads and member nodes. Having their TDMA schedule member nodes sends data to their corresponding cluster head which transfer aggregated data to the base station. Now Cluster head checks periodically the residual energy if its value reaches the e-limit energy, they will reorganize of the cluster to choose a new cluster head through the execution of fuzzy model by member nodes. A proposed fuzzy logic based algorithm has been used to illustrate the cluster head election process. Fuzzy controller design trying to select the optimal cluster head with following three parameters,

They are

- The remaining energy of the node
- The remaining energy of the current cluster head
- The position

The proposed algorithm used some parameters like,

- Fuzzification of the input variable: this uses the remaining battery level of a node. Membership functions: Design uses triangular or trapezoidal membership functions for each input and output.
- Rule base: Proposed fuzzy rules using if then statements to check the energy efficiency.
- Fuzzy interface engine: Provides two different interface systems. They are Mamdani and Sugeno. But they used Mamdani as it gives the accurate values and even for an wide spread acceptance.
- Defuzzification and fuzzy control: Defuzzifier transforms the fuzzy set into crisp value.

Simulations are made under MatlabR2014b using a Windows8 OS on an i5 pc.In this the parameters studied are energy efficiency, energy of cluster head, probability.From the study it is concluded that fuzzy logic increases energy efficiency of cluster heads. To

insure an optimal energy management, each cluster-head have to compare his residual energy with the Relative Energy Level before the initiation of a new round. The system gives as output the probability of a node to become a cluster-head. Based on the probabilities given by the fuzzy module, the new cluster-heads are selected.

Wireless sensor networks are usually powered by batteries and to maintain that batteries is being a fundamental issue in WSN. Using Fuzzy-Logic-Based Energy Optimized Routing for Wireless Sensor Networks proposed by [2] tries to explain about proposed single hop forwarding scheme because it is proved to consume less energy than multihop forwarding scheme within the communication range of the source sensors or a current forwarder, using free space energy consumption model. And achieved energy efficiency and energy balance together by comparing with similar algorithms.

The primary design objective of the routing algorithm is to maximize the network lifetime. They tried to clarify the problem by detailing energy consumption model and data generation patterns and tried to maximize the network lifetime.

Introduced the system model and defines data generation pattern and about energy consumption model. Three data generation patterns are considered as follows.

(i) Uniform data generation: every sensor transmits a data packet to the Sink in each round.

(ii) Random data generation: every sensor reports a data packet to the Sink with probability $p$in each round

(iii) Data generation from a local area: only sensors in a local area have data to be transmitted to the Sink ineach round. The shape of the area can be a circle, asquare, or any other.

Three energy optimized parameters are defined, they are

i. Degree of Closeness of Node to the Shortest Path.

ii. Degree of Closeness of Node to Sink.

iii. Degree of Energy Balance.

A detailed description of fuzzy-logic-based energy optimized routing is explained. A fuzzy system basically consists of three parts: fuzzifier, fuzzy inference engine, and defuzzifier explains and tried to show what exactly Fuzzy membership functions of input and output variables look alike. Evaluated the performance of proposed fuzzy-logic-based energy optimized routing (FLEOR) algorithm via MATLAB.

From the study it is concluded that The fuzzy-logic-based routing algorithm is proposed to realize energy optimized, multiparameter, and fuzzy routing decision.

Fuzzy logic based efficient multipath routing for mobile adhoc networks was proposed by K. Vinoth Kumar and T. Jaya Sankar(2017)[3] talked about the main problems of Mobile Ad-Hoc Networks (MANET). Due to node mobility, heavy packet dropping occurs, which leads to packet overhead and links break. The previous routing protocols are vulnerable to node mobility especially for large-scale networks. Due to this issue, an Efficient Multipath Routing Protocol (EMRP) using fuzzy logic controller is proposed which takes advantage of the stateless property of geographic routing and the broadcast nature of wireless medium. In this protocol, both stability and mobility are calculated to determine network reliability. The reliable multipath is constructed based on network topology. Both link and node reliability is determined to enable novel routing based on calculation of stability. Fuzzy logic control procedure is implemented with reliability to increase the network performance. This system is used in ad hoc network to determine its reliability. The proposed protocol is simulated with Network Simulator (NS2.34) tool to attain better stability and network reliability and also improves the network life time compared to Existing protocols EMLARP

A fuzzy logic based network dependent routing algorithm for ad hoc wireless networks has been proposed by Dr. Sohan Garg and Payal Kansalin[4] They studied on the development of Mobile Ad Hoc network advocates self-organized wireless interconnection of communication devices that would either extend or operate in concert with the wired networking infrastructure or, possibly, evolve to autonomous networks. Unlike traditional wireless networks, ad hoc networks do not rely on any fixed infrastructure. Instead, hosts rely on each other to keep the network connected. One main challenge in design of these networks is their vulnerability to security attacks. Despite the existence of well-known security mechanisms, additional vulnerabilities and features pertinent to this new networking paradigm might render such traditional solutions inapplicable. In particular, the absence of a central authorization facility in an open and distributed communication environment is a major challenge, especially due to the need for cooperative network operation. In MANET, any node may compromise the routing protocol functionality by disrupting the route discovery process. In this paper, we understand the various routing problems related to bandwidth, signal power, mobility and delay. In this paper we are proposing a new routing algorithm that is totally network dependent and will remove the all routing problems.

B. Existing systems

Since the main concern was with wireless sensor networks (WSNs) is the energy constraint to enhance the lifetime of the networks. And there have been several attempts towards saving its energy together with delivering the efficient service. There are many WSN algorithms that have been proposed for efficient clustering as well as cluster head selection such as LEACH and LEACH-C to save energy as much as possible. In the Survey as we saw that most of these algorithms although try to achieve maximum network lifetime still they are lacking behind in enhancing the network life time. So as we studied above most of the cluster head selection

algorithms addresses the shedulablity analysis issues in their proposed algorithms for predictability of network lifetime.

Most routing protocols for WSNs are vulnerable to a number of security attacks, including jamming, spoofing, replay etc. However, because there are cluster-based protocols, they rely fundamentally on the CHs data aggregation and routing. In existing system propose a novel Distributed Energy-aware cost function based routing algorithm (DEFL) that uses Fuzzy Logic approach to improve network lifetime in WSN and provide a generic framework for designing energy-related cost functions.

C. Problem statements

Since wireless sensor networks are resource constrained, inefficient usage of sensor nodes battery power can lead to premature death of the network. Recently, improving energy efficiency of WSNs has gained a lot of popularity. There have been several schemes developed to increase the lifetime of a WSNs. We are addressing these issues associated with WSNs by maximizing the lifetime of WSN using Distributed Energy aware Fuzzy Logic based routing algorithm with hierarchy (DEFL).

D. Proposed system

We propose a heuristic Distributed Energy aware Fuzzy Logic based routing algorithm (DEFL) to significantly improve the network lifetime of wireless sensor networks with heterogeneous nodes and variable traffic loads. Our algorithm is based on shortest path routing strategy with minimum cost. This strategy permits distributed implementation where each node gathers only local information to make independent routing decisions. This approach greatly reduces the communication cost and improves scalability and we are trying to enhance this technique with hierarchical algorithm which improves the battery life as well as reduces the traffic between nodes Most of the HC-WSN clustering algorithms like LEACH and LEACH-C and other algorithms as mentioned in literature that do not work more efficient with protocols like LEACH to enhance the network lifetime.

III. COMPARSION

Table 1: comparing the above four techniques for battery life enhancement.

TECHNIQUES	NETWORK	SYSTEM REQUIREMENTS	COST	BATTERY LIFE ENHANCEMENT
Distributed Fuzzy Logic Based Routing Protocol	Wireless Sensor Network	MATLAB simulation software	High cost	LEACH,CHEF,AND EAUCF by 31.78% 16.74% and 16.74%
Fuzzy-Logic-Based Energy Optimized Routing	Wireless Sensor Network	MATLAB	Low cost	Less than 40% Of its initial energy
Fuzzy Logic Based Efficient Multipath Routing	Mobile Adhoc Networks	NS2(TCL)	Increase the network performance	0.08 WALTS
A Fuzzy Logic Based Network Dependent Routing Algorithm	Ad hoc Wireless Networks	NS2(TCL)	Totally network dependent	High(from 0.6 to 1.0)

IV CONCLUSION

While LEACH seems to be promising protocol, there are few more areas for improvement that makes the protocol more attractive and widely applicable. In this paper, an energy efficient clustering algorithm has been proposed for wireless sensor networks using fuzzy logic concepts. The idea of heuristic Distributed Energy aware Fuzzy Logic based routing algorithm (DEFL) increases the network lifetime dramatically.

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