

Fuzzy Logic for Energy Efficiency of PEGASIS Protocol

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ABSTRACT: Energy Efficiency is the major challenge for any WSN network. As the network nodes are continuously sensing and communicating with each other, they quickly drain out. Several routing protocols have been developed to optimize the energy consumptions. Approaches such as AI and machine learning are also being applied to obtain better performance from classical methods. After the success of LEACH FL; an AI variant of LEACH in the optimization of energy, other protocols are also being tested for the same. This paper discusses the improvement of PEGASIS by applying AI-based approaches to the classical PEGASIS routing approach. It has been observed that the AI-based method performs better under similar circumstances as compared to PEGASIS.

KEYWORDS: Wireless Sensor Network, PEGASIS, PEGASIS FL

I. INTRODUCTION

Wireless Sensor Network is a distributed Network of various sensor nodes [1]. There is no central authority which helps to store the data of nodes in the network. WSN can be self-defined, which is also infra less and self-configure topology. WSN consist of light-weighted nodes. It has deployed sensor nodes. Sensor nodes might be used for sensor system, processing system and communication system (for exchange the data). In this topology, there are internet services that can be used for analysis, storage, processing and mining of data. WSN has various application in various sector or fields such as; medical field, military, environmental sensing, health application, industrial monitoring, agriculture sector, noise level and IoT. WSN is an infra-less structure, so it also has many challenges and issues in the network such as limited energy, fault tolerance, security, limited memory, quality of services, production cost, scalability and hardware constraint. Energy efficiency is the most crucial issue in the network. Energy efficiency is the most exciting topic nowadays among the researchers [2].

II. BACKGROUND AND LITERATURE SURVEY

Energy consumption is one of the standard requirements of WSN[3]. A considerable amount of work has been done for efficiently managing and utilizing the energy stored in WSN nodes. Many issues for energy efficiency due to difficulty to replace the batteries among the nodes in the network, lack of centralized authority and a limited resource to maintain the energy or lifetime of nodes in the sensor network. There are many approaches for the maintenance of the energy of the nodes in the cluster of the wireless sensor network, such as management of topology, cost reduction, change of routing or optimal routing and clustering.

Network Architecture

Figure 1 represents the architecture of WSN [4]. In which sensor nodes wants to talk with the user. For communication, sensor nodes send the "hello" message to all neighbour to check their activation in the environment. The sensor sends the message to the cluster head (CH). The cluster head is that node which has maximum energy among all nodes. The cluster head receives the message from nodes. Then, the cluster node will send the message to the base station or sink. Then, the base station transmits the message to the internet that process, storage and analyze the data and then it will send the data to the user. In this way, the sensor node can communicate with each other.

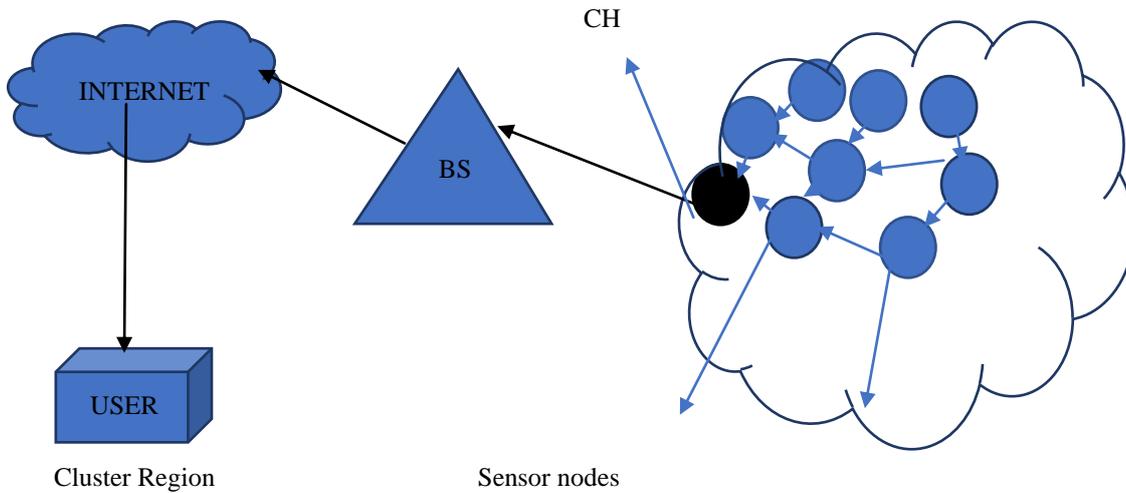


Fig 1 WSN Architecture

Routing Protocol

The Routing protocols help us to resolve the issue of energy in the network[5]. We can implement a different type of algorithms according to the topology of our system. The efficiency of energy can be controlled by using Routing Protocols. Routing protocols can be classified into three categories such as data-centric, location-based Routing and Hierarchical Routing. LEACHFL is also used for energy efficiency in Cluster of Network. So, if we can use FL with PEGASIS, then it might give some better result as compared to PEGASIS.

Comparison of Routing Protocols

Several protocols exist for routing the data from one node to the other during communication. This communication path consumes energy, so it is required to take the routing decisions intelligently and optimize network life. The table below presents the comparison of all such protocols used for routing along with their merits and demerits.

Table 1. Comparison of routing protocol

ROUTING PROTOCOLS	ENERGY EFFICIENT	MERITS	LIMITATION
LEACH [5]	Very low	Leach uses TDMA for unnecessary collisions	LEACH use single-hop communication so it can't be used in a large network
PEGASIS [5]	Low	Energy is distributed equally	The network is not scalable
TEEN [5]	Very high	Well suited for Critical application	Whenever thresholds are not met, the node will not communicate
TCS [5,6]	Medium	TCS reduces the data transmission of the long based chain into smaller chain topology.	Node distributed is not balanced

III. INTRODUCTION TO PEGASIS PROTOCOL AND FUZZY LOGIC

PEGASIS protocol was developed by Lindsey [7]. It was obtained after modification of Leach was done. It is chain-based like the structure of the node. A chain structure is made of each node established communication only with the neighbor node. In the PEGASIS protocol, the transmission takes place via a node to another node. This is done by the help of one node which can be designated to send data to Base station. The Leader node is changed turn by turn during the transmission of data. The Base station determines when it is chain formation by using a greedy algorithm. Generally, it required global knowledge. PEGASIS protocol is an improvement over protocol based on the hierarchical network. The goals of PEGASIS are to lower the overhead of broadcasting; minimize the energy of sensor nodes and

distribution of energy among the nodes in the network is equally and uniformly. PEGASIS protocol is an optimal chain-based protocol. It follows a string-based structure. It generally follows the greedy algorithm. It starts work from the farthest node. It has a goal to transmit the data to all nodes of the network. Each node will get the data or accepted the data from neighbour nodes. The main advantage of PEGASIS is a smaller number of transmissions, so there is less use of energy during communication.

Architecture of PEGASIS

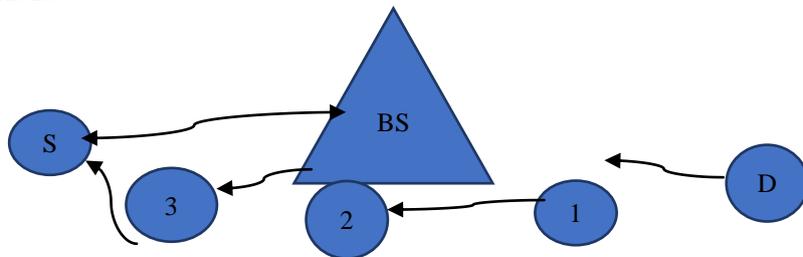


Fig 2 Chain-based topology

Figure 2 represents the chain formation of PEGASIS topology [7]. In this topology, there is one Base Station and Several nodes. Basically, these nodes are sensor nodes. According to this topology, these nodes are connected with each other by a chain in hierarchical order. If the destination node wants to communicate with Base Station then

Table 2. Comparison of Leach and PEGASIS Protocol

LEACH PROTOCOLS	PEGASIS PROTOCOL
● LEACH [4] stands for low energy-adaptive clustering hierarchy	● PEGASIS [4.7] stands for power-efficient gathering in sensor information systems
● It is a cluster-based protocol	● It is a chain-based protocol
● There are a more number of nodes	● There are less number of nodes
● Network lifetime is high	● Network lifetime is higher as compare to LEACH

In PEGASIS protocol[7] there are some merits also; energy load is distributed equally. Reduced overhead due to dynamic cluster formation. Decrease the number of data transmission.

Working of PEGASIS protocol

Some significant steps help us to excuse the PEGASIS protocol.

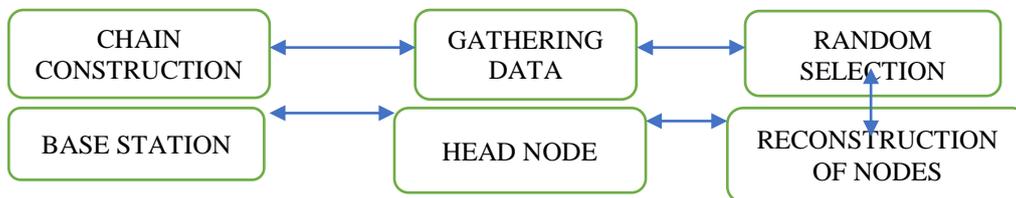


Fig 3 Working of PEGASIS protocol

Chain construction is used for the greedy algorithm in this PEGASIS protocol[7]. Step two is gathering and node is selected as a head node for the total round. A random selection for a node also provides more benefit for nodes if they die at a random location. When any node dies, the chain is reconstructed. Head node receives all data and sends that data to Base Station. Fuzzy logic assigns membership in terms of real numbers that lie between 0 to 1 [8,9]. The value in Fuzzy logic [8] may be true or false. It may be included as an input or an output and might not be useful for complete or accurate knowledge but, then also it provides acceptable results. Fuzzy Logic has four parts given as-

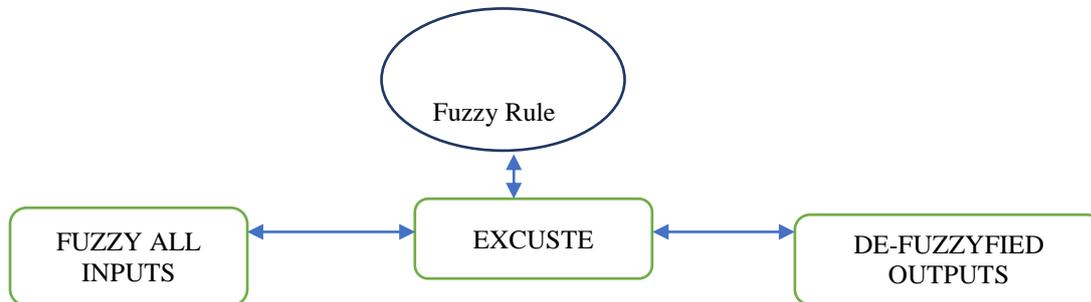


Fig 4 Working of FL

Fuzzification [8,9] is the process of assigning the numerical value that maybe 0 or 1. 0 shows that it does not belong to the fuzzy set. If 1, then it belongs to the fuzzy set. Defuzzification[8,9] is to get a continuous variable fuzzy value. Application of Fuzzy logic is used in various field in our routine life such as aerospace field; neural network; speed control; traffic control.

IV. IMPLEMENTATION

PEGASIS protocol is used for energy-efficient in the network. In this, we use Fuzzy Logic[8] with PEGASIS protocol to get the optimal solution based on residual energy with a number of rounds and number of nodes are alive or dead.

Simulation Parameter

The model of the simulation is described as below-

- A network is consisting of 100*100 topology
- The distribution of nodes is throughout the same
- At an early stage, the nodes will send the message "Hello" to all neighbour nodes to check them; they are in an active state or not.

Table 3. Parameter Values for WSN Network

PARAMETERS	VALUES
Network Size	100*100
Number of nodes	100
Number of rounds	10000
Initial energy	0.5KJ

The result of PEGASIS is shown in the figure in the form of energy with respect to the number of rounds with 100 nodes.

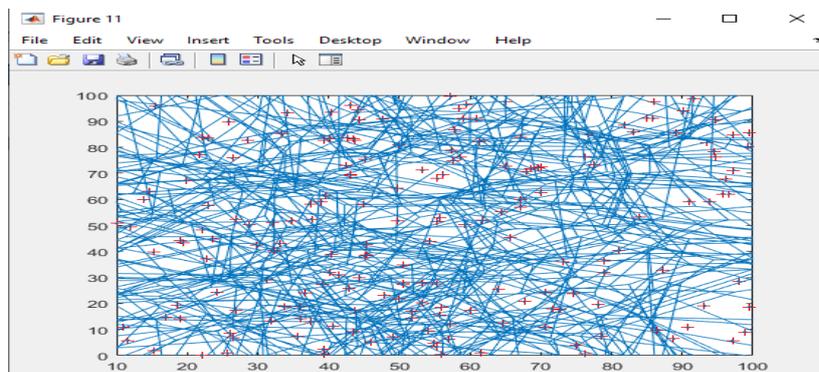


Fig 5 Chain formation of nodes in PEGASIS

Figure 5 represents the formation of a chain with having a leader node to send and receive the data from the sensor node (neighbour node).

V. RESULT AND DISCUSSION

This section presents the result obtained using the simulation parameters described above. The PEGASIS and its Fuzzy version is compared under the same simulated environment.

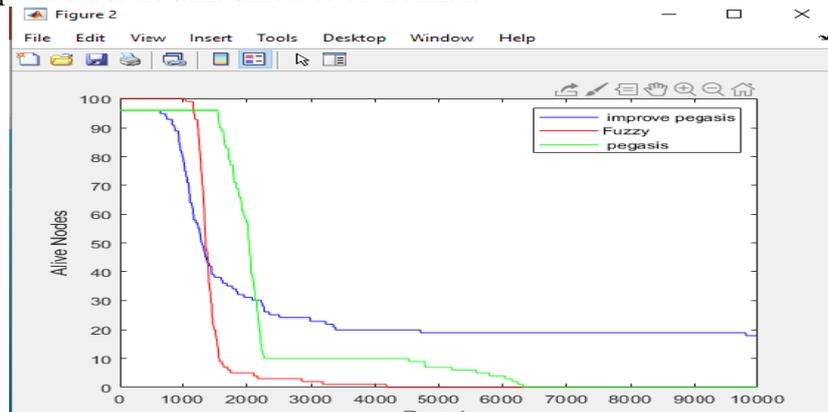


Fig 6 Alive nodes VS number of rounds

Figure 6 represents how many nodes are alive in-network concerning the number of rounds. At 90% probability, we can quickly analyze the result in terms of live nodes. In fuzzy logic-based method, the number of nodes died early as compared to PEGASIS.

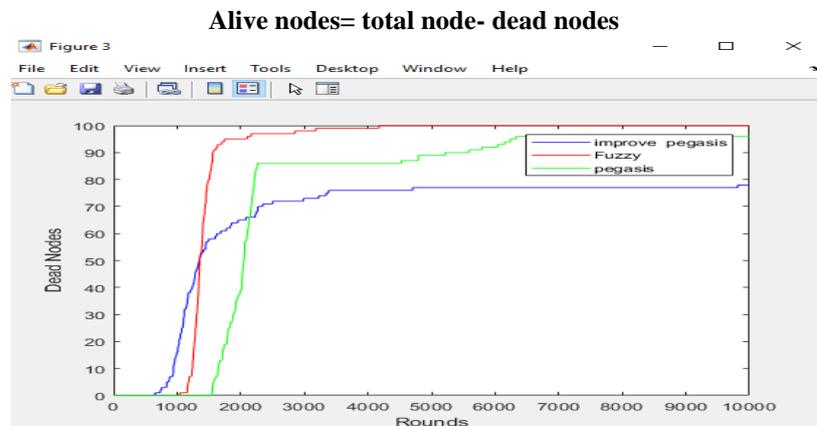


Fig 7 Dead nodes VS number of rounds

Figure 7 represents how many nodes are dead in-network with respect to a number of rounds. At 90% probability, we can quickly analyze the result in terms of dead nodes. Here also in the fuzzy logic-based method, the number of nodes die early as compared to PEGASIS.

Dead nodes= total node- alive nodes

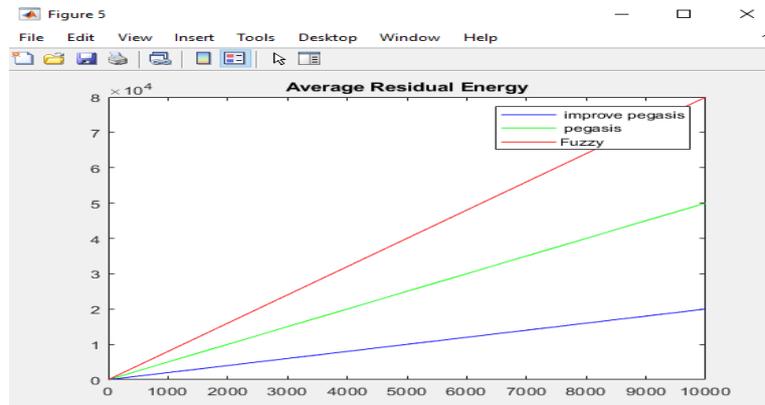


Fig 8 Average residual energy VS number of rounds

Figure 8 represents the result in the term of average residual with respect to the number of rounds.

VI. CONCLUSION

In this paper, a comparison of two hierarchical routing protocols – PEGASIS and PEGASIS FL is presented. Our analysis shows that improved PEGASIS that uses Fuzzy logic performs better than PEGASIS in terms of network lifetime. This improved version saves the time for execution of the total number of rounds. The number of alive nodes is more in improved PEGASISie Pegasis FL as compared to classic protocol

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