Clustering WSN Using Fuzzy Logic and Genetic Algorithm

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Abstract— In general, wireless sensor networks possess a number of sensor nodes that are capable of sensing, computing and communicating. Usually these are placed in atmosphere to get the data related to natural parameters like temperature, humidity, pressure etc,. In order to sense, compute and communicate the data, the sensor node utilizes some amount of energy from its battery source. The main drawback of wireless sensor networks is that each sensor node is energy limited, which means that a node can survive and function for a limited period of time. Thus the sensor node's have small lifetime. This affects the whole sensor network lifetime. But it can be improved by undergoing a technique called Clustering. Many protocols were presented to perform this clustering. The main task in clustering is the election of cluster head. Previously LEACH protocol was used, where it ended up with random distribution of sensor nodes in the Wireless sensor network. Here we come up with fuzzy logic and genetic algorithm to elect the cluster head. Here, the Fuzzy module is used in sensor node and the genetic algorithm in the Base Station or SINK. First step involves in the process of nomination for being a cluster head takes place and the second step involves in selecting the best among the nominated nodes as a cluster head for that particular cluster. Thus the nomination process in first step uses the Fuzzy Logic and the selection process in the second step uses the Genetic Algorithm. This could really optimize the energy consumption of sensor node and thereby increase the network lifetime.

Key words: Clustering, Network Life time, Cluster Head Selection, Fuzzy logic in Sensor nodes, Genetic Algorithm

I. INTRODUCTION

As a product of the development and combination of the sensor technology, embedded computer technology, wireless communication technology and distributed information processing technology, Wireless Sensor Networks (WSNs) provide a kind of brand-new information acquisition and processing method, and have broad application prospects in military, environmental protection, agriculture and health and other fields [1,2].

A Wireless Sensor Network is composed of many number of sensor nodes and each performs actions like sensing, computing and communicating. Thus the main function of the sensor node is to send data to the base station through a wireless medium. Each sensor node requires some energy to perform this data transfer. Nodes are generally in-built with energy source (a battery), but is limited. Considering each sensor node sends the data individually to Base station, the nodes that are far away from the base station consumes more energy compared to the nodes present nearer to the base station. Thus the far away nodes die sooner and finally affect the life time of whole network.
Research has shown that network nodes organized into groups called clusters, can be more efficient in reducing energy consumption, which leads to increase the network lifetime. The network lifetime is the interval running protocol up to the first dead in Nodes [3]. Thus, the clustering is made in Wireless Sensor Network before sending the data to base station.In Clustering, the sensor nodes divide into groups to form clusters. In each group, one sensor node is selected as a cluster head and it receives aggregated data from the respective sensor nodes present under its area. Then the Cluster Head's alone communicate with the Base station. This could merely optimize the energy consumption of the sensor nodes, except the cluster heads.

The main step in performing clustering is the selection of the cluster head. Here this process is carried out using Fuzzy Logic and Genetic Algorithm. Fuzzy logic is a control methodology and also a way of processing data based on the membership function. Fuzzy logic concerns with the reasoning and mathematical representation of human concepts[4]. The Fuzzy module being embedded in the sensor node with set of well defined rules, gives us the qualification level of that particular node for being a cluster head. The Genetic Algorithm used in the Base station then chooses the best among the qualified nodes and elect them as the cluster head.If once the cluster head is decided, then the corresponding member nodes will send the data to that particular Cluster Head and these Cluster Heads aggregate the data received and then sends the required data to Base station. Then it is said to be completion of one round. After each and every round, the base station again checks the energy levels of the sensor nodes and clustering is performed if needed.

The Cluster Head is mainly selected based on the Fitness parameter. Fitness parameter is defined by the qualification level of sensor node. Fitness parameter belongs to Genetic Algorithm used and it is defined by the Qualification level obtained using Fuzzy Logic.In this paper, we introduce fuzzy logic and Genetic Algorithm for performing Clustering and Cluster Head selection process. Also defining a good relation between Fuzzy logic and Genetic Algorithm in accomplishing these tasks. Here Fuzzy logic involves in defining the qualification level based on two input parameters namely, Energy and number of neighbour nodes (Density). The heuristic approaches based on Fuzzy Logic and Genetic Algorithm can prove to be efficient for wireless sensor networks [5][6].Earlier, LEACH protocol was used for cluster head selection. But, the main problem of LEACH protocol is it only depends on the probability model to elect the cluster head and therefore it is possible that no cluster heads or too many are selected in a single round [7].

II. OBJECTIVE

The main aim of this discussion is, to increase the network lifetime by optimizing the energy consumption of sensor nodes through efficient Clustering approach that uses fuzzy logic and genetic algorithm at its best. The improved network life time allows the WSN to exist a bit longer

period and to serve the application (in which it is being used) in full stretch with extended lifetime.

III. METHODOLOGY

In this paper, we used fuzzy logic and genetic algorithm to perform clustering in wireless sensor networks. This process is carried out in two different stages. The first stage uses the fuzzy logic to evaluate the qualification levels of the sensor nodes for being cluster head. The second stage utilizes the GA in the Base station to select the best among the qualified nodes as cluster heads. Then the optimized clusters are formed.

A. First stage :

Initially a wireless sensor network is created with randomly distributed sensor nodes within the specified area. The Fuzzy module is placed into each sensor node (MOTE). The fuzzy module consists of a Fuzzy Logic Controller (FLC). The main element of the FLC is the Fuzzy Inference System invoked with set of well defined rules.

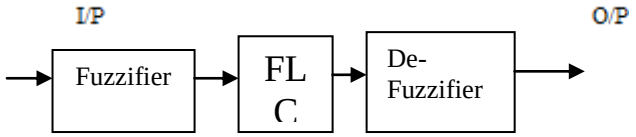

Fig. 1: Fuzzy Module

1) Fuzzifier :

The Fuzzifier decides how the crisp input will be converted into a fuzzy input to be used by the inference engine.

2) Flc :

The Fuzzy Logic Controller consists of Fuzzy Inference Engine that decides how to process the rules written in it using the fuzzy inputs from the fuzzifier.

3) De-fuzzifier:

The De-Fuzzifier decides the way to convert the fuzzy result from inference engine back into a crisp value.

Every sensing element sends their energy and density parameters into the fuzzy module present in them. Fuzzy module generates the output by reading the rules written in it. Now, from the output value obtained, a timer gets activated for each sensor independently and starts numeration down from it. The sensing element with top fitness value will get its timer reaches zero quicker. This means that particular node is fit enough and is qualified for being a cluster head. This qualification analysis is performed by keeping one of the input parameter as constant and varying the other.

Thus, in the 1st stage, the process of nomination of the sensor nodes to become cluster head is being carried out.

4) Fuzzy Rules used :

1. If (energy is low) and (NoN is low) then (localqualification is vsmall) (1)
2. If (energy is low) and (NoN is med) then (localqualification is small) (1)
3. If (energy is low) and (NoN is high) then (localqualification is rsmall) (1)
4. If (energy is med) and (NoN is low) then (localqualification is midsmall) (1)
5. If (energy is med) and (NoN is med) then (localqualification is med) (1)
6. If (energy is high) and (NoN is low) then (localqualification is rl) (1)
7. If (energy is high) and (NoN is med) then (localqualification is large) (1)
8. If (energy is high) and (NoN is high) then (localqualification is vl) (1)
9. If (energy is med) and (NoN is high) then (localqualification is medlarge) (1)

Fig. 2: Fuzzy Rules

B. Second stage :

In the second stage, Genetic Algorithm comes into the picture. The Genetic Algorithm used in the Base station is now used to select the best among the nominate one as cluster head. The Genetic Algorithm performs this by reading the fitness levels of the nominated (Qualified) nodes. The best among the nominated nodes are further selected from their fitness parameter only. If once the cluster head is selected, the particular heads send their ID and position values to the base station. The Base Station then broadcast the message to the remaining sensor nodes, where it details about the selected Cluster heads.

Now, the Cluster head selection is completed. The normal nodes after receiving the broadcast message regarding the Cluster heads, determine which cluster they should join in this round based on the strength of the signal they received. After determining which cluster they should belong, CSMA Protocol will be used to send a confirmation message to their cluster heads. At this point, the clusters formation is completed.

After forming the clusters, the Genetic Algorithm considers the best fit Sensor nodes and performs the cross over and mutation functions to produce the best future population if needed. The formed Clusters are will not remain same for the further rounds. If the energy consumption of the nodes in that cluster for that particular round is efficient, then the Genetic algorithm doesn't disturb that cluster and allows the same format of cluster for the next round. Thus, the clusters may vary from one round to another. If any node looses it complete energy and dies, then that particular node is removed from the respective cluster. The mentioned clustering and cluster head selection processes occur continuously for each and every round of data transfer.

IV. SIMULATION AND RESULTS

The proposed algorithm was simulated using MATLAB software. The output of two different stages has shown separately. Some of the parameters that are considered initially for simulation are given below,

Parameter	Value
Initial Population	150
No. Of. Clusters	5
Selection length	2
No. Of. Rounds	300

Table 1: Parameters And Values

A. First stage:

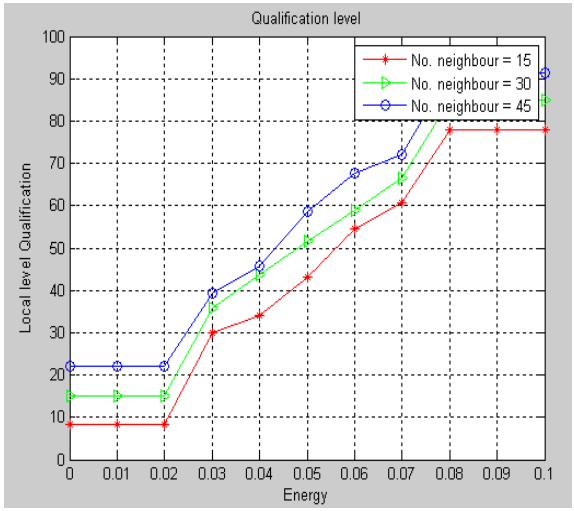

Fig. 3: Qualification Level (a)

Here, the Density (No. of Neighbour Nodes – NoN) is kept constant and for varying energy values, the qualification level of the sensor nodes is analyzed and is plotted.

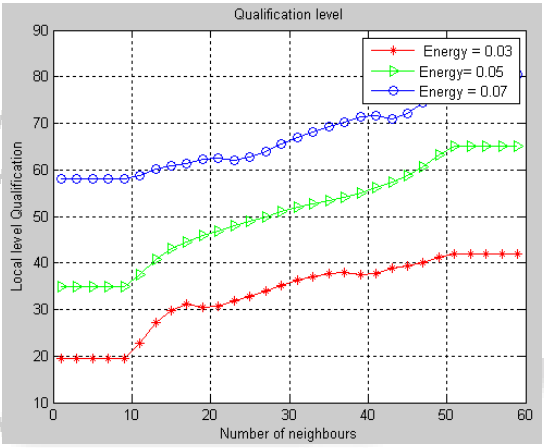

Fig. 4: Qualification level (b)

Here, the Energy is kept constant and for varying Density (No. of Neighbour nodes – NoN) values, the qualification level of sensor nodes is analyzed and is plotted.

B. Second stage :

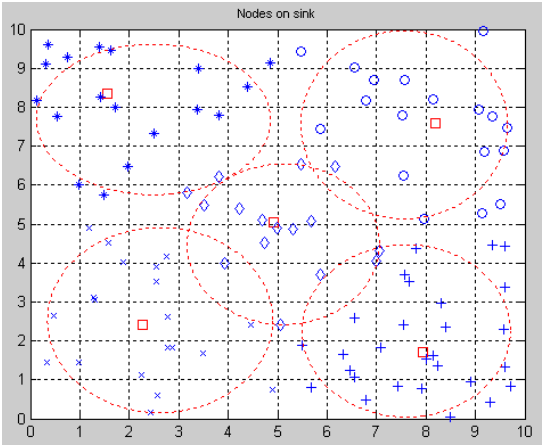

Fig. 5: Cluster formation and Cluster Head selection

Thus, at the end of the second stage, the clusters are formed and the efficient cluster heads are selected.

V. CONCLUSION

In this paper, we proposed a better clustering and cluster head selection approach using Fuzzy Logic and Genetic Algorithm. Both the entities are used at their best to optimize the energy consumption of sensor nodes. In this paper, we use a fuzzy module which is run in a distributive manner in all nodes in order for the best node in each region to be known at the base station as a candidate for the cluster-heads and by implementing genetic algorithm centrally at the base station, we have determined the best cluster-heads in such a way that we would have the minimum energy consumption in the network. Creating balance and uniformity of the nodes, energy consumption and longer network's lifetime are the achievements of using the proposed algorithm in this paper.

VI. REFERENCES

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