The Combinations of Selected Parameters to Prolong the Network Lifetime for Cluster Head Selection in Wireless Sensor Network

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Abstract—In Wireless Sensor Network, parameter selection is one of the important considerations to help the usage of the energy while selecting the cluster head in clustering scheme. This paper proposed the right combination of the parameter to select the cluster head in order to minimize the total energy consumption required for data collection and aggregation. We proposed three parameters which are residual energy, centrality and communication cost and blended all together using Fuzzy Logic method. By using these proposed parameters, we will able to compare the energy usage for each of the nodes with LEACH and SEP algorithm. Simulation results show that, the right combination of parameters may produce good results and tends to prolong the lifetime of the sensor network.

Keywords- wireless sensor network, cluster head, energy efficiency, parameters

I. INTRODUCTION

Wireless sensor networks (WSNs) made of sensor nodes that are deployed over an area of network. The main purpose of the deployment is to monitor certain phenomena of interest such as military surveillance, landslide detection, physical environment, health field and so on. Normally, WSN are deployed hundreds or thousands [1] of integrated sensor nodes to sample the data from observed environment with a low cost devices. Once deployed, sensor nodes collect the data / information, compress it and then send to the base station. The base station collects data from the nodes, analyze all the data before conclude the overall activities in the area of interest [2]. In practice, it is impossible to recharge the batteries in WSN due to the large quantity of sensor nodes. With the small size of the sensor nodes, the energy provides to its is too limited [3]. This tends to influences the network operations. Therefore, this is the main reason why the network lifetime is a main concern while designing the sensor network.

In WSN, communications are using more energy, so energy conservation must be considered while designing a good technique in WSN. Thus, there are many approaches have been implemented such as Low Energy Adaptive Clustering Hierarchy (LEACH) [4], Power Efficient Gathering in Sensor Information Systems (PEGASIS) [5], Stable Election Protocol (SEP) [6], A Hybrid Energy-Efficient Distributed Clustering Approach for Ad-Hoc Sensor Network (HEED) [7], An Energy Aware Fuzzy Unequal Clustering Algorithm For Wireless Sensor Network [8]. Due that, LEACH was firstly algorithm that proposed clustering routing protocol which is known as a adaptable for a huge network and it can drastically prolonging the lifetime of the sensor network [9].

In LEACH, during the startup phase, each of the sensor nodes will become a cluster head (CH) with fixed probability. Other sensor nodes that not become a cluster head will join the cluster which is the nearest to the CH and this CH used more energy rather than non CH. All communication from sensor node to the base station will go through the cluster head for each of the cluster. The cluster head will aggregate the data and then send the data to the base station. There are maximum number of packets data that should CH carried from each of the sensor nodes [10] and this might have the CH reach its capacity to handle the data. Therefore, CH normally die on early phase [2]. So, the effective techniques should be considered to prolong the lifetime of the sensor node and the network lifetime.

This paper proposed an Effective Combination Parameters (ECP) using Fuzzy Logic approach to prolong network lifetime. Firstly, the process will focus on identifying the criteria of the parameters to determine the best parameter while designing the WSN algorithm. The parameter selection is important to conserve energy while selecting cluster heads because the right combination of the parameters will produce good result in term of power
consumption of sensor network. The rest of this paper is organized as follows. Section II, describes the related works. Section III explores the parameters and Fuzzy Logic operational. Section IV explains the simulation parameters and analysis of the result. Final section concludes this work.

II. RELATED WORKS

This section will review the related work in clustering algorithms. Clustering is a main focus in WSN. It is to improve the longevity of network lifetime. The advantages of clustering is to reduce the communication overhead while transmitting the data [11]. Weighted clustering [12], hierarchical clustering [13] and dynamic clustering are some of the several clustering method that have been successfully implemented [14]. There are many ways to select the cluster head in clustering. Basically, a lot of algorithms select cluster heads based on certain weights, most favorable cost function, or found heuristic to generate minimum number of clusters. So, right combination of parameters also can be one of the most important variables to be considered in order to prolong the lifetime of the sensor network.

Many routing algorithms have been proposed to optimize the energy consumption of the sensor network [15]. In [8] the purpose of the research is to solve the problem in clustering which is hot spots issues in multi-hops. Authors in [16] select the cluster head using fuzzy logic approach in order to long lasting the sensor network. The authors suggest a two level, one is on local level and another is global level to prolong the network lifetime. Authors in [17] proposed F3N to overcome the problem of sensor nodes characteristics using different condition by comparing it with LEACH algorithm. Researches in [18], [19], [20], [21], shown that there are some problem include sensor nodes clustering, selection of cluster head and energy dissipation. Those researches are deals with that challenge.

Our experiment is closely related to the LEACH but the main objective of this experiment is to select the best secondary parameter to be combined with main parameter which is energy in order to get the most effective parameter to be compared with LEACH and SEP algorithm.

III. PARAMETER SELECTION

The proposed parameter are based on the [22] which the combination of the parameter will be used for cluster head selection in order to maximize the lifetime of the network. The parameter involves are residual energy, centrality and communication cost. Residual energy can be defined as a remaining energy level that is available at each node whereas the centrality is the central position of the node it clusters, while the communication cost is the shortest path to be route to reach the certain location. [23]. For the centrality, the lowest value of the centrality contributes to the less of energy usage to transmit the data to the base station. All the parameters will be blended into Fuzzy Logic function.

A. Fuzzy Logic Approach

![Fuzzy Logic Control Structure](image)

Fuzzy Logic can make a real time decision although there is no complete information about the situation. Fig. 1 shows the basic elements of the Fuzzy Logic Control (FLC). FLC contains sets of fuzzifier, inference engine, Fuzzy Rules Base as shown in Table 1, and defuzzifier.

<table>
<thead>
<tr>
<th>Residual Energy</th>
<th>Centrality</th>
<th>Communication Cost</th>
<th>Chances</th>
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The input variables have 3 linguistic groups, so it indicates the total possible number of fuzzy inference rules is:

\[ |T(Residual\ Energy)\ |x\ |(Centrality)\ |x\ |(Communication\ Cost)\ |\] [1]

where the \(|T(x)|\) is the number of groups. These denote \(3 \times 3 \times 3 = 27\) rules. So there will be 27 outputs variables for each parameter. The outcome to represent the node cluster head election chances was divided into three levels which are strong, medium and weak. The example for Fuzzy Rules Base; if the residual energy is high, the centrality is far and the communication cost is high, then the chances for the sensor node to become a CH is medium. The structure for
the control rules is; IF “group” THEN “chances”. The rest of the Fuzzy Logic Rules was defining as in Table 1.

Fig. 2 shows the fuzzy inference system for the three parameter suggested. The input parameters involved are residual energy, centrality and the communication cost. All the parameters will be blended into Fuzzy Logic and the output chances was represent by trapezoid function.

Fig. 3 shows the fuzzy variables for the “Residual Energy”. There are three fuzzy sets which are high (H), medium (M) and low (L). The chances to become a CH denote by membership functions. The chances are based on triangular function and trapezoid function.

Fig. 4. Membership functions for parameter centrality.

For the centrality, there are also have three fuzzy sets which are far (F), near (N) and satisfactory (S) as shown in Fig. 4.

Fig. 5. Membership function for parameter communication cost.

High (H), medium (M) and low (L) are three fuzzy sets that represent the parameter of communication cost as shown in Fig. 5.

IV. SIMULATION RESULTS

The simulation was simulated using Matlab programming based on LEACH and SEP protocol. The total numbers of nodes tested are 100 nodes and this testing is based on 5000 iteration.
Fig. 6 shows the experimental result for the dead node after 5000 rounds of iterations. First parameter tested was combination of residual energy and centrality (ResCen), followed by residual energy with communication cost (ResComm), and the last experiments was combination of residual energy, centrality and communication (Fuzzy3). Referring to Fig. 6, the combination of parameter ResCen, the node dead after 5000 rounds was 85 sensor nodes rather than 84 nodes dead if used combination of ResComm parameters. The best combination of parameter represent by Fuzzy3 where, these combination of three parameter tends to have only 10 nodes dead after 5000 rounds. This is improve the selected parameter compared to LEACH which is all nodes dead after 5000 iteration and 99 nodes dead for SEP respectively. Proof that, using three parameter can prolong the lifetime of the sensor nodes.

Fig. 8 shows the total data received at the base station for LEACH, SEP and using proposed parameter based on Fuzzy techniques. The packets received to the base station using Fuzzy techniques was 25000 compared to the LEACH and SEP which were only 15000 and 14000 packets received respectively. This simulation proof that, the data packets safely arrived to the base station with the highest values using proposed method.

V. CONCLUSION

The network lifetime of the wireless sensor network is an important issues to be highlighted. From its routing protocol, network design, the algorithm until the selection of the parameter should be addressed. This experiments tested on the right combination of parameters to be selected. The consideration of the used several parameters instead one parameter is important to prolong the lifetime of the sensor nodes.

In order to get the most effective combination of parameters, this study proposed three combination of parameters using Fuzzy Logic and it was compared with LEACH and SEP protocol. By using Fuzzy Logic method, the three parameters can be blended together and results shows that less total nodes dead and the total number of packet to the base station is the highest compared to the LEACH and SEP. Further experiments will test these sets of parameter into the multi-tier clustering which focus on the selection of the cluster head for each of the clusters.

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