IMPROVED CLUSTER HEAD SELECTION USING FUZZY LOGIC IN WIRELESS SENSOR NETWORKS

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ABSTRACT

Energy efficiency is a key issue in the design of wireless sensor networking systems because each sensor node Carries power source of limited capacity and cannot be easily replaced. Despite significant advancements in wireless sensor networks (WSNs), energy conservation remains one of the most important research challenges. In designing the Wireless Sensor Networks, the energy is the most important consideration because the life time of the sensor node is limited by the battery of it. This paper deals with study and analysis of simulation the investigating power consumption in wireless network and investigating the possible way to reduce the power consumption at Base Station. To overcome this demerit many research approaches have been done. The clustering is the one of the representative approaches. Proper organization of nodes (clustering) is one of the major techniques to expand the lifespan of the whole network through aggregating data at the cluster head. The cluster head is the backbone of the entire cluster. To achieve high energy efficiency, a typical approach is to cluster the sensor nodes in some way so that energy is conserved. In this paper, a fuzzy logic approach to cluster-head election is proposed based on four descriptors –remain energy, neighbor distance, concentration and centrality. Simulation shows that depending upon network configuration; increase lifetime can be accomplished as compared to other probabilistic model proposed for selecting the nodes as cluster-heads.

Keyword: Clustering, Cluster head Selection, Fuzzy Logic, LEACH, Wireless Sensor Networks

I. INTRODUCTION

Recent developments in wireless communication Technologies have enabled wireless Sensor Network A Wireless Sensor Network (WSN) regularly checks physical or environmental conditions and sends the collected data to a Base Station (BS) through network. Wireless sensor network (WSN) is composed of a large number of sensor nodes that are connected to each other to perform specific tasks .Recent developments in wireless communication technologies have enabled Wireless Sensor Networks(WSNs) to be deployed for many applications such as unexpected event detection and disaster relief operations. The Wireless Sensor Networks(WSNs) consist of a large number of small and cheap sensor nodes that have very limited computation capability, energy and storage. They usually monitor some area, collect data and report to the base station. Recently, due to the achievement in low-power digital circuit and wireless communication, many applications of

the WSNs are developed and already it is used in military object, habitat monitoring and object tracking[1][3]. Moreover, the WSN is one of the most important research areas to provide context aware services in the ubiquitous computing environment[8].There are various challenges in wireless sensor networks because its special features. The most challenging aspect of such networks is they are energy resource-constrained and that energy cannot be replenished. This limitation makes it essential for developed protocol to improve the performance of such networks by conserving energy and consequently increasing the network's lifetime. Designing the WSNs is very difficult because the sensor nodes have limited computation capability, limited power and small memory size[7]. To overcome energy waste energy in a WSN, as surveyed in[4] many experiments proved that cluster-based WSN routing protocols excel network topology management and energy minimization. In fact, clustering methods by aggregating data into single paths is increasing the efficiency of required energy and also accuracy of communication. In these factors ,the energy consumption is the most important one because the battery is not changeable if once the sensor nodes are deployed. The energy is also the major consideration in designing the routing of the WSNs.

There are diverse applications of intelligent techniques in wireless networks [4].**In this paper,**We use a fuzzy system with appropriate inputs to overcome the weakness of LEACH. Fuzzy logic control is capable of making real time decisions, even with incomplete information. Conventional control systems rely on an accurate representation of the environment, which generally does not exist in reality. Fuzzy logic systems, which can manipulate the linguistic rules in a natural way, are hence suitable in this respect. Moreover it can be used for context by blending different parameters - rules combined together to produce the suitable result. a fuzzy logic approach to cluster-head election is proposed based on **four** descriptors The inputs that we consider in the fuzzy system are: **neighbors distance, centrality, energy remaining,** *and concentration* .

These parameters are not so closely related and can easily work with these heterogeneous parameters by Using fuzzy logic. Also a fuzzy system does not need much computational complexity; consequently it is suitable for WSN. Simulation shows that depending upon network configuration a substantial increase in network lifetime can be accomplished as compared to probabilistically selecting the nodes as cluster-heads using only local information.

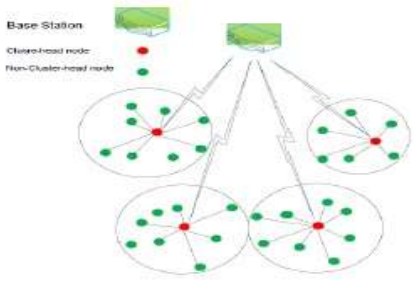


Figure 1. WSN architecture

The rest of this paper is organized as follows. In section 3, LEACH will be briefly discussed and one of the cluster head election mechanisms that use the fuzzy logic will be introduced. In section 4, we define the base model of WSNs .In section 5, the proposed Fuzzy based cluster head election mechanism will be introduced. In section 8, we evaluate our mechanism compared with LEACH by simulation. Finally, in section 9, we will summarize our paper and discuss about future research.

II. RELATED WORK

In this section some of the recent clustering approaches are explained. A typical WSN architecture is shown in Figure 1.The nodes send data to the respective cluster-heads, which in turn compresses the aggregated data and transmits it to the base station.

For a WSN we make the following assumptions:

• The base station is located far from the sensor nodes and is immobile.

• All nodes in the network are homogeneous and energy constrained.

• Symmetric propagation channel.

• Base station performs the cluster-head election.

• Nodes have location information that they send to the base station with respective energy levels

• Nodes have little or no mobility

III. LEACH

The first well known protocol developed by Heinzelman et al is LEACH (Low Energy Adaptive Clustering hierarchy with Deterministic Cluster-Head Selection) [1].LEACH [1] is one of the clustering mechanisms to achieve the energy efficiency in the communication between sensor nodes. In each round, sensor nodes elect itself as a cluster head based on probability model .to become a cluster head, each node n chooses a random number between 0 and 1. If the number is less than the threshold T(n), the sensor node elects itself as a cluster head and advertises this fact to other nodes around the cluster head. The nodes that receive this message calculate the distance between the cluster head and itself and send a join-message to the closest one of the cluster heads to form a cluster. the node becomes the cluster-head for the current round.

The Threshold is set at:

$$T(n) = \frac{p}{1 - p \times \left(r \bmod \frac{1}{p}\right)} \quad , if\ n \varepsilon G$$

$$T(n) = \quad 0 \quad \text{,otherwise} \qquad (1)$$

Equation (1) defines the T(n) where p is the requested ratio of the cluster heads in the WSNs and r is the count of current round. The G is the set of sensor nodes that were not elected as a cluster head in last 1/p rounds. According to Equation (1), every sensor node elects its self as a cluster head only once during 1/p rounds. In this way, The energy concentration on cluster heads is distributed.

Several disadvantages are there for selecting the cluster-head using only the local information in the nodes.

However, LEACH has some critical points.

1. LEACH depends on only the probability model.eachnode probabilistic decides whether or not to become the cluster-head, there might be cases when two cluster-heads are selected in close vicinity of each other increasing the overall energy depleted in the network.
2 .Each node has to calculate the threshold and generate the random numbers in each round, consuming CPU cycles.

3. LEACH does not consider the energy remains of each node so the nodes that have relatively small energy remains can be the cluster heads. This makes the network lifetime be shortened.
4. The number of cluster-head nodes generated is not fixed so in some rounds it may be more or less Than the preferred value.
5. The cluster head may be located in the edge of the network or in the place where the node density is very low. In this case, Many nodes in that cluster inefficiently consume energy in communicating with the cluster head.
6 the distance can be measured based on the wireless radio signal power.
7 Once deployed, the nodes dose not move.
8 The base station is located in the center of the WSNs.

IV. BASIC SYSTEM MODEL

The basic system model of this paper is depicted in Figure1. Each sensor node sends the sensed data to its cluster head. The cluster head aggregates the collected data and transmits the aggregated information to the base station.

This operation is general in the WSNs. Here are some assumptions for our mechanism.

-The WSNs consist of the homogeneous sensor nodes.

-The distance can be measured based on the wireless Radio signal power.

-Once deployed, the nodes dose not move.

-All sensor nodes have the same initial energy.

- The base station is located in the outside of the WSNs.

V.CLUSTER-HEAD ELECTION USING FUZZY LOGIC#

From the above defects of LEACH, we can find that an efficient cluster head election mechanism should not depend only on the probability. To achieve high energy efficiency, gathering and calculating other information that could affect the energy consumption may occur heavy overhead. Recently,Gupta [2] proposed that the overhead of cluster head election may be highly reduced by using fuzzy logic. Similarly In our proposed mechanisms four fuzzy variables (remain energy, Neighbor distance, concentration and centrality) were used for fuzzy if-then rule. These variables are defined like follow.

- Remain Energy - energy level available in each node
- Concentration - number of nodes present in the local distance r vicinity
- Centrality - a value which classifies the nodes based the energy concentration on cluster heads is distributed.
- Neighbor distance -the sum of distances between the node and the nodes which is within r distance

In other fuzzy logic mechanisms the base station collects the energy and location information from all sensor nodes and elects the cluster heads using fuzzy if-then rule according to the collected fuzzy variables. They probed that fuzzy logic can prolong the network life time efficiently. However, this mechanism has some demerits.

- This operation may be very complex because The base station has to collect information of all Sensor nodes Which produce more overhead.

VI. FUZZY LOGIC CONTROL

Fuzzy logic (FL)is defined as the logic of human thought, which is much less rigid than the calculations computers generally perform. Fuzzy Logic offers several unique features that make it a particularly good alternative for many control problems. It is inherently robust since it does not require precise, noise-free inputs and can be Programmed to fail safely [11, 12].The model of fuzzy logic control consists of a fuzzifier, fuzzy rules, fuzzy inference engine, and a defuzzifier. We have used the most commonly used fuzzy inference technique called Mamdani Method [G 8] due to its simplicity. The process is performed in four steps:

- Fuzzification of the input variables energy, concentration and centrality - taking the crisp inputs from each of these and determining the degree to which these inputs belong to each of the appropriate fuzzy sets.
- Rule evaluation - taking the fuzzified inputs, and applying them to the antecedents of the fuzzy rules. It is then applied to the consequent membership function (Table 1).
- Aggregation of the rule outputs - the process of Unification of the outputs of all rules.
- Defuzzification - the input for the defuzzification process is the aggregate output fuzzy set *chance* and the output is a single crisp number.

The fuzzy system used in the inference engine of the expert system is the Mamdani fuzzy system. The Mamdani fuzzy system is a simple rule-base method which does not require complicated calculations and which can employ the IF…THEN… rules to control systems. Mamdani was the person who used the fuzzy method for the first time to study the process of controlling steam machine. Since then, this method has been in use and has acquired a special status[7]. All the rules in the rule-base are processed in a parallel manner by the fuzzy inference engine. Any rule that fires contributes to the final fuzzy solution space. The inference rules govern the manner in which the consequent fuzzy sets are copied to the final fuzzy solution space. Example, techniques are MIN-MAX and fuzzy adaptive method. The defuzzifier performs defuzzification on the fuzzy solution space. That is, it finds a single crisp output value from the solution fuzzy space. Some of common defuzzification techniques are: Center of Area (COA), Center Of Gravity (COG), Extended Center of Area (ECOA), Mean of Maxima (MeOM)and etc. In this paper we use COA method for defuzzification [6].

VII. THE PROPOSED MECHANISM

In this section, we introduce CHEF which uses fuzzy if-then rule to maximize the lifetime of WSNs. this is similar to the [6] but uses the **neighbor cluster head election mechanism** that the base station does not need to collect information from all nodes.

In our opinion a central control algorithm in the base station will produce better cluster-heads since the base station has the global knowledge about the network. Moreover, base stations are many times more powerful than the sensor nodes, having sufficient memory, power and storage. In this approach energy is spent to transmit the

location information of all the nodes to the base station (possibly using a GPS receiver).Considering WSNs are meant to be deployed over a geographical area with the main purpose of sensing and gathering information.

The fuzzy system inputs are crisp numbers that converted to the fuzzy values by membership functions. The nodes simply determine these input values. The nodes is aware of Neighboring nodes and their distance, As soon as one sending and receiving data.

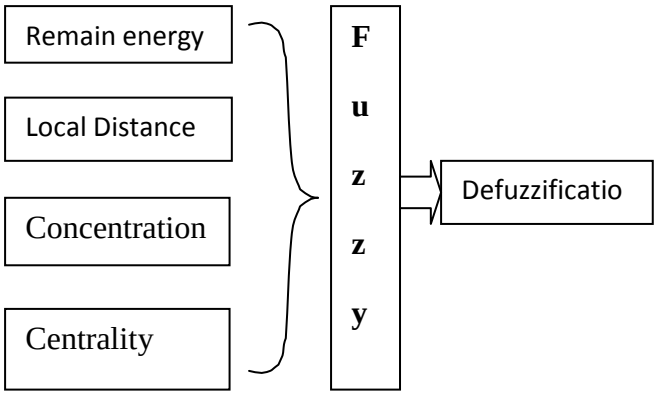


Figure 2. fuzzy Cluster Head Election system

Fuzzy System(FIS)calculates a chance using fuzzy if-then rule. The bigger chance means that the node has more chance to be a cluster head. To compute a chance, we will use two fuzzy variables - energy and local distance. Figure 3 and Equation(3) describes how the local distance is calculated. The sensor node A can calculates a chance from the variable energy which is the energy remains of the node A and the variable local distance which is the sum of distances between then node A and the nodes which is within r distance.

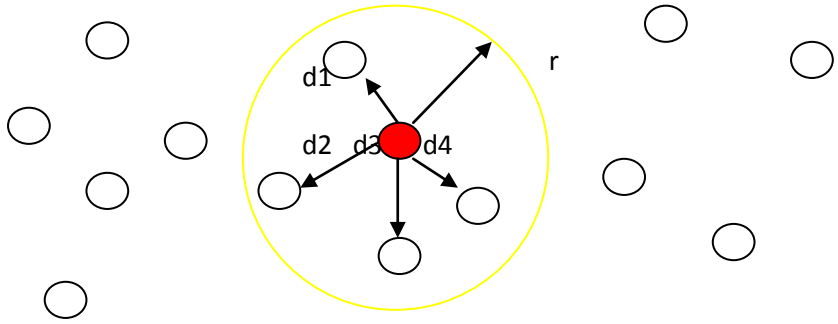


Fig.3 Distances between the node A and other nodes within r

Local Distance = dl + d2 + d3 + d4 (3)

The r is the average radius of the preferred cluster. Equation(4) shows how we can calculate it. The n is the total number of sensor nodes in the WSNs.

$$r = \sqrt{\frac{area}{\pi \times n \times p}} \qquad (4)$$

Based on the Above fuzzy variables, we can define a fuzzy if-then rule like Table I. The detailed the fuzzy sets of remain energy, local distance, concentration and centrality we obtain chance of selecting a cluster head are described in Figure4.

During defuzzification, it finds the point where a vertical line would slice the aggregate set *chance* into two equal masses. In practice, the COG (Center of Gravity) is calculated and estimated over a sample of points on the aggregate output membership function, using the following formula:

$$COG = \left(\frac{\sum \mu a(x) * x}{\sum \mu a(x)} \right) \qquad (4)$$

where, μa(*x*) is the membership function of set A.

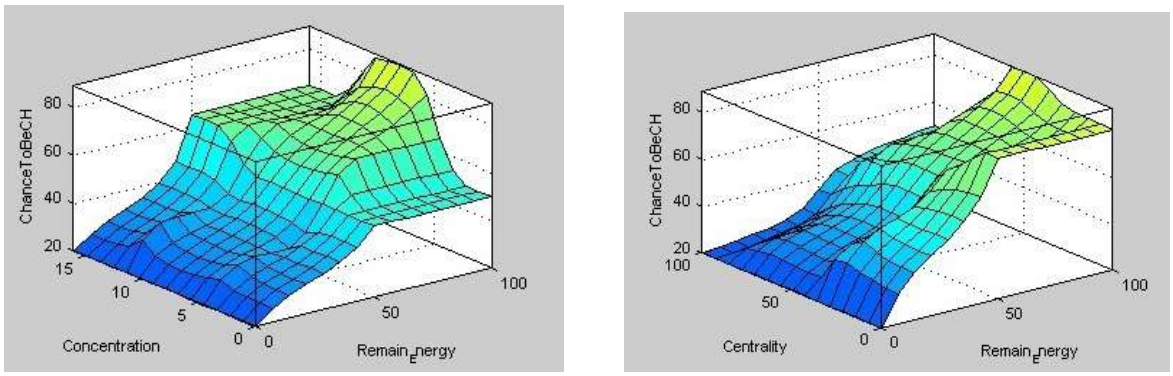
7.1 Fuzzy Logic Membership Functions and Rules

The advantage of fuzzy system is the ability to cope with linguistic uncertainty. Following are main rules used to obtain chance of selecting CH. now we use fuzzy inference method to determine output from inputs..some rules that mamdani method uses them are listed in table I. The fuzzy rule base currently includes rules like the following: if the *energy* is *high* and the neighbor distance is close , *concentration* is *high* and the *centrality* is VHigh then the node's cluster-head election *chance* is *very large*.

Table.1 Some fuzzy Rules

Energy	Neighbors Distance	Concentration	Centrality	Chance to be CH
High	Close	High	Close	VHigh
Medium	Far	Low	Close	VLow
High	Adequate	High	Medium	High
Low	Close	Low	Close	Low
Medium	Far	Medium	Far	Low
Medium	Adequate	Medium	Medium	Medium
Low	Adequate	High	Close	Medium
Medium	Close	Low	Close	Low
High	Far	Medium	Far	Medium
Medium	Adequate	Low	Close	Low
Low	Far	High	Close	Low
Low	Close	Low	Medium	Medium
High	Adequate	Low	Close	Medium
Low	Close	High	Far	VLow
Medium	Close	Medium	Far	Low
High	Far	Medium	Medium	Medium
Low	Far	Medium	Far	VLow
High	Close	Low	Medium	High
Medium	Adequate	High	Close	Medium

With the help of above rule we draw following graph



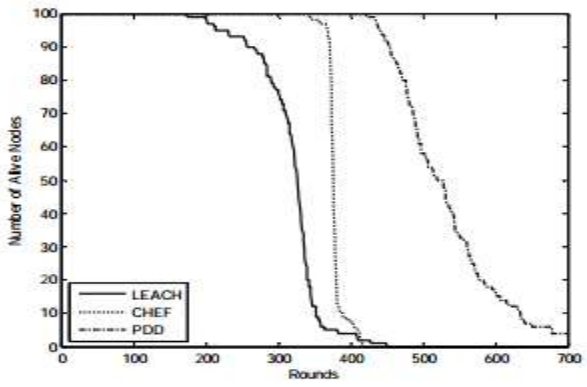
(a) concentration and energy remaining **(b) centrality and energy remaining**

Fig 4 Comparison of the Surfaces

VIII. SIMULATION RESULTS

We use of Matlab [11] for simulations of our network. This simulation shows that energy remaining in cluster node. Also shows difference between proposed method and LEACH and other fuzzy system in energy consumption. Consider that the proposed method consumes less energy than other method and thus the network lifetime increased. It is clear from fig 5 that our proposed method does work well as compare to other method.

To compare with LEACH and proposed method, the networks that have an area of 100*100 (which varies in each run)and with fuzzy logic we selected proper cluster head . The coordinate of the BS is (10,50) and the energy parameters are shown in fig 5.



Fig,5 The Comparison of alive nodes given the same initial energy

IX. CONCLUSION

Our aim of doing this research is to achieve an Optimal energy efficiency, approach for clustering in WSN. the energy is the major factor in designing the WSNs. LEACH is the representative one. LEACH uses the probability model to distribute the concentrated energy consumption of the cluster heads. However, it only

depends on the probability model and the energy efficiency is not maximized. This paper has discussed a novel approach for cluster-head election for WSNs.This method has less computational complexity because uses of fuzzy logic. Since all operations for cluster formation are done locally a large amount of energy is saved and speed of cluster formation is increased. Moreover, this method is extremely robust because using appropriate input for the fuzzy system. We propose an efficient clustering approach by combination good features of LEACH approach and fuzzy logic. This method works better than other clustering approaches .a network with real time data as input to fuzzy system of nodes can be tested in the future with further experiments.

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