A Fuzzy Logic-based Clustering Algorithm: Review

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ABSTRACT

Wireless sensor network(WSNs) presents a new generation that conducts a model of real-time embedded system with limited computation, memory, communication, and energy resources which are being used for vast range of applications where mostly traditional networking infrastructure is practically unobtainable. The energy is the chief agent in designing of WSNs. Sometimes it is impossible and impractical to replace the battery and to maintain longer lifetime of the network when nodes are densely disposed in a competitive environment to monitor, detect and evaluate the physical phenomenon. To attain the energy powerfulness, the clustering is a typical issue. Legitimate CHs are elected to minimize energy consumption and improve the lifetime of the network. Low energy adaptive clustering hierarchy (LEACH) is one most glorious clustering mechanism. But it depends on stochastic model and energy efficiency is not boosted. In this paper fuzzy logic approach has been used forselection Super cluster Head among CHs is based on threefuzzy descriptors such as battery power, Mobility and centrality which are used to minimize energy consumption and enhance the lifetime of the network than LEACH.

Keywords
WSN, Fuzzy logic,SCH.

1. INTRODUCTION

Wireless Sensor Network is designed to be a real time embedded system dispose in a selective region with limited energy and memory resources which are being used to sense the various types of environmental parameters such as temperature, pressure, gas, humidity etc.WSN is used in a broad departure of applications where conventional networking framework is practically unachievable. Several useful and various applications of WSNs contain information about inhospitable environments, weather and climate monitoring, biological agent threats, healthcare monitoring, forest fire detection, surveillances, transport monitoring etc. These applications are in demand for the usage of various appliances including cameras, aural tools and sensors to determine different physical parameters [3].

Typically, WSNs are densely disposed in dangerous places where battery recharge or restoration is almost impossible but human monitoring scheme is highly delicate. There are many illustrative arguments such as limited computing capacity, power necessity, open environment, radio connectivity accomplish the sensor nodes injured many times. In WSN, there are some disadvantages of the sensor nodes in terms of energy supply, Bandwidth, Computational capabilities [6]. Once the network is fixed, all nodes accumulate on sensing the information and the battery potential goes exponential. Whenever any event recognize by nodes they send the information to the other nodes or to the base station. Sometimes it appears the same information is acquired by adjacent sensor nodes and can be acquired by the base station that makes thenetwork ineffective.To escape this data repetition and to make the network energy effective, many routing protocols had been used with different ideas [20]. One

of these economic ideas is Cluster based routing protocol, where sensor nodes are divided into number of gangs and each gang is called as cluster. In each cluster one gang controlleris selectedwhich is known as Cluster Head (CH). Data gathering is accomplish at the controller node. Message sending to the BS is only permitted by the controller node/CH. The CH nodes accumulate the data anddirectly transmit to the base station (BS). Absolutely the CH nodes act as gateways between the sensor nodes and the BS. Clustering protocols are classified as both static and dynamic

Appropriate cluster-head node selection can extremely decrease the energy of dissipation and enhance the network for lifetime. In LEACH, the CH is elected in a stochastic manner and tries to balance the load at each sensor node in each revolution. Figure 1 shows the general system model for clustering based WSN.
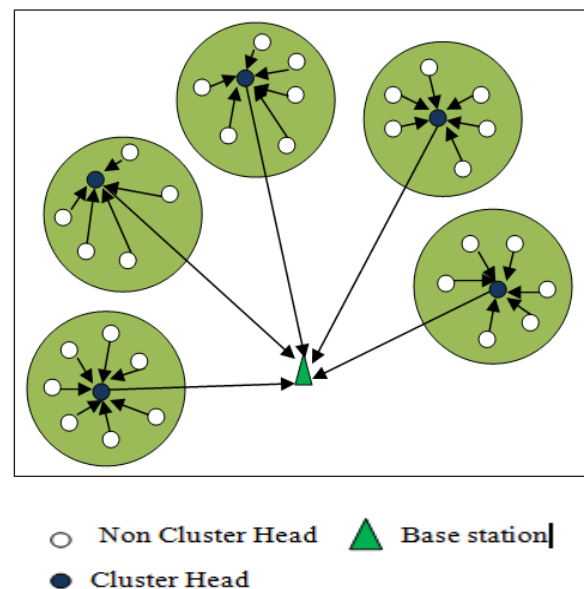

Figure 1: General System Model for clustered WSN.

Although many present researches show the power of LEACH protocol, it has some limitation that essential to be explained. Sometimes the CHs selected may be very close to each other because LEACH depends only upon stochastic model. While LEACH reckon on stochastic value, it might appear that more than oneCHs are selected or no cluster head is selected in each round. Sometimes the cluster head may be selected at the edge of the network, which makes energy allotting unsuitable. The Super-CH (SCH) is selected among the CHs which gathersthe data from CHs and it allows only send the information to the mobile BS by selective suitable three fuzzy descriptors, such as remaining battery power, mobility of BS, and centrality of the clusters. Fuzzy inference engine (Mamdani's rule) is used to select the chance to be SCH. Most of the fuzzy clustering protocols [6] did notexactlyselect the CHs i.e. first select the progressive CH and after that select the final CHs.

The rest of this paper is classified as follows. In section 1define introduction, In section 2 discuss the related work of clustering, Protocols areexplain briefly in section 3,Advanced apparatus fuzzy based cluster head selection are indicates in section 4. Fuzzy logic model explain in section 5. Discussion about the future work in section 6.

2. RELATED WORK

In the past, many algorithms had been proposed and are mostly based on routing algorithms to optimize the energy consumption. LEACH [15] is the hierarchical routing protocol, while the CHs selected are based on stochastic model and onlyCHsresponsible for information is sent to the BS. LEACH-C [13] is a centralized passage for choosing cluster heads by BS in WSNs. PEGASIS [12] is improvement over LEACH protocol and incline covered by hierarchical network routing protocols. TEEN [14] and APTEEN [11] are another two proposed protocols in time-critical applications improvement lifetime of the network. Gupta et.al [10] proposed FREEDOM *(Fault Revoking and Energy Efficient Protocol for the Deployment of Mobile Sensor Nodes in Wireless Sensor Networks)*with presentation of the mobile sensor nodes to enhance the energy powerfulness of the WSN by renewal of a spoilt node by a mobile node. BCDCP [4] (*Base station Controlled Dynamic Clustering Protocol*) is an appendix of the LEACH-C by dividing each cluster an equal number of nodes. Kim et.al [7] proposed CHEF (*Cluster Head Election mechanism using Fuzzy Logic*) used two input parameters energy and proximity distance for the selection of cluster head. Sharma et.al [1] proposed F-MCHEL (*Fuzzy based Master Cluster Head Election Leach*) approach as better than CHEF.

Indranil Gupta, et al. presented nodes elected as a cluster-head from sensor nodes which can intensely reduce the energy consumption and enhance the lifetime of the network. Fuzzy logic approach got used to select cluster-head which was presentedbased on three descriptors - energy, concentration and centrality.LEACH used the cluster head based on a stochastic model. The results were the proposed technique Fuzzy logic to select the CHs as compared to stochastic model, selecting the nodes as cluster-heads using only local information to reduce the waste energy and enhanced the lifetime of the network [5].

Jong - Myoung Kim, et al. presented that the energy is the chief agent in designing of WSNs. To attain the high energy efficiency, the clustering is a typical issue. LEACH is one of the most glorious clustering mechanisms. It depends onstochastic model but energy efficiency is not boost.To attain high energy efficiency using fuzzylogicfor select the CH. The proposed protocol CHEFto compute the CHs chance, by used two fuzzy variables - energy and local distance. Base station had no required to collected the location information from all sensor nodes so overhang occurred reduced. The results of the proposed CHEF compare with LEACH to select the CHs. The results computed that CHEF is 22.7% more energy efficient and prolong lifetime of network than LEACH [6].

Md. Abdul Alim et al. presented that total lifetime and energy powerful of the network is important argument in LEACH, where excellent number of clusters is the unachieved and that is one of the main advantages of the proposed algorithm. The proposed energy efficient progressive clustering protocol fuzzy logic is used to select the CHs by Base station used rounds. BS determines the fuzzy cost based on two input variables which are node centrality and residual energy in generic rounds. The achieved fuzzy based algorithm was better than LEACH in items of FND (First Node Dies), HNA (Half of Nodes Dies) and LND (Last Node Dies).The results of the proposed fuzzy logic algorithm is compared with LEACH to select the CHs. The results computed that by using fuzzy logic prolong the total lifetime of the network by 11.5% and is more energy efficient than LEACH [9].

3. CLUSTERING PROTOCOLS

In this section, most of the hierarchical routing protocols where cluster heads are selected in an energy powerful aspect are discussed. Also concentrated on some clustering protocols based on fuzzy logic. Each cluster head is responsible for gathering the information from the corresponding cluster, compresses in one message and sends to the Base station. Most essential protocols are given here with fuzzy logic and without fuzzy descriptors. Following assumptions are taken for WSN:

- All sensor nodes have equal initial energy considered as homogenous networks.
- Base station is mobile.
- Except Base station all sensor nodes are static.

3.1 Hierarchical Routing Protocols based on Clustering

3.1.1 LEACH

LEACH [13] [15] is a hierarchical routing protocol which has equal chance to become a CH and selects the CHs based on stochastic model.This protocol operates in two phases, one is set up phase and another is steady state phase. The nodes form the cluster in set up phase and in steady phase actual data is transmitted. To become CH each node selects the random number between 0 and 1. For current round the node access chance to be the cluster head if the number is less than threshold value T(n) is defined in equation (1).

$$T(n) = \begin{cases} \frac{p}{1-p*\left(r mod \frac{1}{p}\right)}, if n \epsilon G \\ 0, otherwise \end{cases} \qquad (1)$$

Where r is the round, P is the probability of nodes to be cluster head, G is the set of nodes which have never CH at end 1/p rounds. Although distributes equal load on each cluster head by LEACH protocol, still there are some disadvantages that need to the discussed.
These are:

• There are possibilities that elected two cluster head closed to each other that dissipation energy in the network because it select CHs based on stochastic model.
• If the selected node is placed near to the edge of the network, transfer of the message to CH by other nodes dissipates more energy.
• In each round, one irregular number is induced and calculates the threshold value so more CPU cycles are consumed.

3.1.2 LEACH-C

Centralized approach used in LEACH-C to select the CHs by BS, in which location information and energyof each node knownby BS. The position of each node is must be known by BS this is the main limitation of centralized protocol.

3.2 Fuzzy Logic Based Clustering Protocol

Many researchers had showed up with many different ideas as to how Fuzzy Logic (FL) could be exploited to select the proper and capable CH so that worthwhile life time can be

proficient. Some of the FL based clustering algorithms are discussed below.

3.2.1 CHEF

In CHEF [16] selected CHs by fuzzy logic approach is based on four descriptors- remain energy, neighbor distance, concentration and centrality. Fuzzy based elected CH in CHEF [1] used two input parameters which are proximity distance and energy. Simulation result shows that by 22.7%, CHEF is better than LEACH. In [17], the author examined three fuzzy parameters such as energy,concentration and centrality to determine the chance to be the CHs. But main limitation of this protocol is that nodes are not assembled with GPS receivers and they do not arrange information in some locations.

3.2.2 F-MCHEL

In F-MCHEL [1] selected CH based on Fuzzy rules using parameters energy and proximity of distance. Among the CHs, which node has more energy to select the Master Cluster Head (MCH) and only responsible to assemble the data and send to the BS. In [19], proposed protocol to select the Super Cluster Head (SCH) among the CHs by used three Fuzzy descriptors such as remaining power, mobility, and distance to BS. The network remains constant when mobility increases or decreases, that is the limitation of this protocol. To overcome this drawback considered centrality third input parameter in Fuzzification module in the proposed protocol [19].

4. ADVANCED APPARATUS

Fuzzy logic is used to human decision making convention and to model human action. In addition it can hold confused real time applications highly precisely than the stochastic model. The extreme welfare of using FL is to defeated the overhang of collecting and calculating energy and location information of each node. Ultimate the FL based clustering algorithms consult the sink node/BS as stable. Nowadays there is a tendency to examine sink or BS mobility that can console the network traffic, decrease suspension and enhance the energy capability [20]. The fuzzy used three descriptors such as remaining battery power, mobility, centrality to calculate for chance to be suitable SCH elected and can only SCH send the information to the BS. In Figure 2 shows the cluster model with CHs and SCH.

Remaining battery power has been considered to be metric because it estimates that in every round, energy level of each CH gets decreased. Centrality is concentration on location of SCH as how it is disposed centrally to transmission with another CHs. Mobility suggests that whenmoves BS in aespecial direction, the distance increase or decrease between BS and SCH with respect to speed and direction of moving BS.
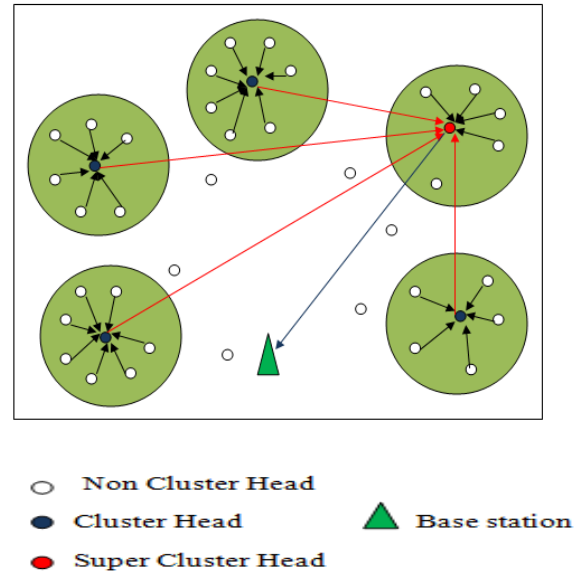

Figure 2: Cluster model with CH and SCH.

5. FUZZY LOGIC MODEL

Fuzzy logic modelcontainsof four modules: a fuzzifier, fuzzy interference engine, fuzzy rules and a defuzzifier, The most broadly used Mamdani's method[20]. In Figure 3 shown the block diagram of fuzzy interference system.
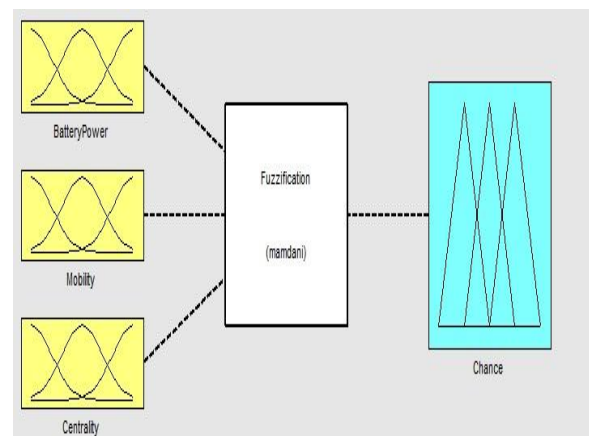

Figure 3: Fuzzy system for the Proposed Model.

For completion of the process, four steps arerequired given below:

1) *Fuzzification:* The inputs are disposed with crisp value and changed in to the fuzzy set in fuzzifier.

2)*Rule evaluation:* It stores the IF-THEN rules.

3)*Fuzzy Inference Engine:*The fuzzy inference system (FIS) is a process that uses the fuzzy set theory to map from given inputs to outputs.It takes both input values and IF-THEN rules for simulate the process. Fuzzy inference system havebeen strongly enforced in fields such as automatic control, decision analysis, expert system and computer vision.

4) *Defuzzification:* It transforms in crisp value from fuzzy set.

There are 27 rules are used the fuzzy interference. The rules in the form is if X,Y,Z then C. X means remaining battery power, Y means mobility, Z means the centrality and C means the chance. The membership functions for input variables are used given in table 1 and output variable given in table 2.

Table1.Membership Functions For Input Variables.

Membership Function		
Remaining Battery Power	Mobility	Centrality
Less(0)	Low(0)	Close(0)
Medium(1)	Moderate(1)	Adequate(1)
High(2)	Frequency(2)	Far(2)

Table 2.Membership Functions For Output Variables.

Membership Function
Chance
Very weak(-1), weak(0), lower medium(1), medium(2), higher medium(3), strong(4), very strong(5)

Table 3.Fuzzy Rules And Value Of Chance

Remaining Battery power	Mobility	Centrality	Chance
Less(0)	Low(0)	Close(0)	Very Weak(-1)
Less(0)	Low(0)	Adequate(1)	Weak (0)
Less(0)	Low(0)	Far(2)	Lower Medium (1)
Less(0)	Moderate(1)	Close(0)	Weak (0)
Less(0)	Moderate(1)	Adequate(1)	Lower Medium (1)
Less(0)	Moderate(1)	Far(2)	Medium (2)
Less(0)	Frequent(2)	Close(0)	Lower Medium (1)
Less(0)	Frequent(2)	Adequate(1)	Medium (2)
Less(0)	Frequent(2)	Far(2)	Higher Medium (3)
Medium(1)	Low(0)	Close(0)	Weak (0)
Medium(1)	Low(0)	Adequate(1)	Lower Medium (1)
Medium(1)	Low(0)	Far(2)	Medium (2)
Medium(1)	Moderate(1)	Close(0)	Lower Medium (1)
Medium(1)	Moderate(1)	Adequate(1)	Medium (2)
Medium(1)	Moderate(1)	Far(2)	Higher Medium (3)
Medium(1)	Frequent(2)	Close(0)	Medium (2)
Medium(1)	Frequent(2)	Adequate(1)	Higher Medium (3)
Medium(1)	Frequent(2)	Far(2)	Strong (4)
High(2)	Low(0)	Close(0)	Lower Medium (1)
High(2)	Low(0)	Adequate(1)	Medium (2)
High(2)	Low(0)	Far(2)	Higher Medium (3)
High(2)	Moderate(1)	Close(0)	Medium (2)
High(2)	Moderate(1)	Adequate(1)	Higher Medium (3)
High(2)	Moderate(1)	Far(2)	Strong (4)
High(2)	Frequent(2)	Close(0)	Higher Medium (3)
High(2)	Frequent(2)	Adequate(1)	Strong (4)
High(2)	Frequent(2)	Far(2)	Very Strong (5)

6. CONCLUSION AND FUTURE WORK

In this paper, a review of fuzzy based energy powerful protocols for WSNs has been discussed. A lot of research has been conducted to improve energy consumption and routing in LEACH protocol. But LEACH depends only on stochastic model so energy power doesn't get widen. The CHs are elected by LEACH and Super cluster Head elected among Cluster Heads by using fuzzy concept. In future scope will focus on saving overall energy of the network by using fuzzy logic for choosing appropriate both CHs and SCH.

7. ACKNOWLEDGMENTS

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