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Enhanced Fuzzy Logic-Based Clustering Algorithm

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Abstract: In previous few years the use of wireless sensor networks (WSNs) are increasing excessively in different applications such as disaster management, security vigilance, border security, battle field exploration etc. Sensors are habitual to dispose subordinately in huge numbers and correlative with each other where human associated is not basically achievable. These tiny sensor nodes are executed by battery power and the battery executed sensor nodes cannot be quickly recharge or replaced. So, minimization of energy consumption is an important issue to prolong the lifetime of network. To resolution this issue, sometimes sensor nodes are joined to form a cluster Head (CH). In each cluster, elected a controller node that is called as Cluster Head. Each node senses the environment, when recognize any event and send the information to the respective cluster heads. After then the cluster heads send the information to the Base station. So, suitable cluster head election can decrease appreciable amount of energy utilization. But in this passage, a super cluster head (SCH) is elected among the CHs who can only responsible for send the information to the Base station. In this paper, we propose both CHs from clusters and SCH among the CHs are elected by choosing suitable fuzzy descriptors, such as remaining battery power, mobility of BS, Centrality, Base station Route.

Keywords: WSN, Fuzzy logic, CH, SCH.

I. INTRODUCTION

Wireless Sensor Network designed as actual time embedded system utilize` in a appropriate region with limited energy and memory resources that are being used to sense the several types of environmental criterion such as temperature, pressure, gas, vaporization etc. The tremendous applications of WSN like habitant monitoring, forest fire detection, vigilance, transport monitoring etc. Demand of these applications the usage of distinct apparatus along with cameras, audio, infrared and seismic tools and sensors calculating different environments, for example in militant scenarios, track down several risks. Thus these networks can aggregate brilliance in battlefield, track, terrorist lines, eaves-dropper likely destructive synthesized and nuclear constituent using neutron based detectors.

Generally, WSN are dimly disposed in insecure vicinity where battery recharge or recovery is infeasible nearly but human monitoring scheme is exceptionally endangered. Wireless connectivity makes the sensor nodes injured many times, there are various descriptive contention such as fixed calculate contents, power necessity, open environment. Some limitations of the sensor nodes in feature of energy source, Bandwidth, Computational capacity in the Wireless sensor network [6]. Once the network is fixed, all nodes accumulate on observe the data and the battery power life goes exponentially. The nodes send the information to other nodes or to the base station whenever they detect any event. The network makes inefficient, Consistently it arrive that the corresponding acquired information by the neighbouring sensor nodes and can be acquired similar information by the base station that generate the faulty of the network. Data duplication is the major problem in the WSN, to avoid this data repetition and make network reliable using many routing protocols with different ideas have been proposed in literature [14].

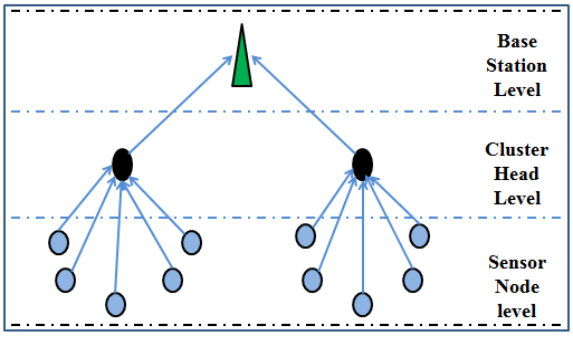

Fig. 1 General System Model for clustered WSN

Data duplication is the major problem in the WSN, to avoid this data repetition and make network reliable using many routing protocols with different ideas have been proposed in literature [14]. Cluster based routing protocol is one of these powerful ideas, in which all sensor nodes are divided into number of gangs and each gang is called cluster. One gang controller is elected in each cluster that is called as Cluster Head (CH). All nodes send the information to the CHs for respective clusters; they compress it and send to the Base station [5]. The message sending to the BS is only responsible by leader node/CH. The CH nodes actually act as the gateway between the BS

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and sensor nodes. Figure 1 shows the general system model for clustering based WSN. Legitimate CHs elected to the decrease energy consumption and improve the lifetime of the network. In the proposed illustrate, electing relevant CHs from clusters and SCH among the CHs by applying Type-1 Fuzzy logic descriptors, remaining battery power, mobility, centrality, BS route. The succeeding segments examine the protocol in detail. The rest of the paper is classified as follows. Section II examine about clustering protocol in this field. Section III presents the proposed protocol. Discuss Simulation results and analysis in section IV. Indicate the future work in section V. Conclusion discusses in section VI.

II. CLUSTERING PROTOCOL

A. Hierarchical Routing Protocols based on clustering

1) LEACH: LEACH [13] [15] is a famous hierarchical routing protocol which has equal chance to become a CH and proven to be most efficient over traditional routing protocol. It elects the CHs based on stochastic model and tries to balance the load at each sensor node in the rotation basis. This protocol operates in two phases; one is set up phase and second is steady state phase. The nodes form of the cluster in set up phase and actual data is transmitted in steady state phase. Each node selects a random number between 0 and 1 to become CH. For current round the nodes gets chance to be the cluster head if the number is less than threshold value T (n) is defined in equation (1).

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

Where r is the round, p is the probability of nodes to be cluster head, G is the set of nodes which have never been CH in the end 1/p rounds. Although in LEACH distributes equally load on each cluster head, still there are some drawbacks that need to the discussed here.

- LEACH depends only on stochastic model so elected cluster heads may be very close each other.
- If the elected CH node is placed near to the edge of the network, message transfer to CH by another nodes dissipate more energy.
- In each round one random number is induce and calculate the threshold value so more CPU cycles are consumed.

2) LEACH-C: Centralized approach used in LEACH-C to elect the CHs by BS, each node location information and energy known by BS. The main limitation of LEACH-C is that the location of all nodes essential be known by BS.

B. Fuzzy Based Clustering Protocol

Many researchers have spring up with many different ideas how Fuzzy Logic (FL) can be exploit to elect the proper and able CH so that worthwhile life time can be proficient. Some of the FL based clustering algorithms are discussed below:

1) CHEF: In CHEF [13] elected CH is based on two criterions which are contiguity range and energy. The fuzzy based passage elects the node to be the CH with big energy and regionally perfect node. Simulation result occurrence that the CHEF is 22.7% more effective than LEACH. In [12] the author has examined three Fuzzy parameters such as energy, concentration and centrality to determine the chance to be the CHs. But main limitations of this protocol all nodes are not assembled with GPS receivers and they ability not be able to accommodate locus information in few places.

2) F-MCHEL: In F-MCHEL [1] elected CH based on Fuzzy rules used criterions energy and contiguity of distance. Among CHs which node has more energy to elect the Master Cluster Hear (MCH) and only responsible to assemble the data and send to the BS. In [14] the proposed protocol to elect the Super Cluster Head (SCH) among CHs by used Fuzzy descriptors such as remaining power, mobility and Centrality. The network remains constant when mobility increase or decrease that is the limitation of this protocol. To overcome this drawback has been examined BS Route as the fourth input parameter in Fuzzification module in this proposed protocol.

III. PROPOSED PROTOCOL

The proposed protocol is termed as Enhanced Fuzzy logic-based clustering protocol, its performance is calculate using different benched noticeable parameters like Packet sent versus round, Faulty nodes versus round, Energy of nodes versus round, Network lifetime. The main purpose of the proposed protocol to choose appropriate Cluster Head in the clusters and elect Super cluster Head among the CHs. The [14] elected the CHs by using Leach Protocol and elected SCH from CHs using Fuzzy descriptors such as remaining battery power, mobility of BS and centrality of the clusters. The Leach protocol is depend only stochastic model, So the proposed protocol to elect both CHs from the clusters and SCH among the CHs using Fuzzy descriptors such as remaining battery power, mobility of BS and centrality of the clusters, BS route. As a result it shows that our proposed approach results are much better than existing approach. After the results we are comparing the proposed approach against the existing methods.

A. Network Model

For illustration if there are N nodes randomly allocated over M × M region and K clusters are pretended, then there are N⁄K nodes per cluster (one CH and (N⁄K)-1) Non cluster Head nodes. In proposed model, it is assumed that the sensor nodes are considered to be randomly deployed to monitor the environment continuously in a square area. Assumption is made that all nodes in the network has following properties:

- Except the base station all the sensor nodes are static, means there is no movement of nodes once they are deployed.

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- Homogeneous network have been examined such that all the nodes are same and have the same initial energy at the beginning.
- The base station is mobile.
- Nodes do not posses any GPS apparatus so the distance between the node and the base station can be calculate based on received signal strength.

B. Fuzzy Logic Model

Fuzzy logic model contains of four modules: a fuzzifier, fuzzy interference engine, fuzzy rules and a defuzzifier, In Figure 2 shown the block diagram of fuzzy interference system.

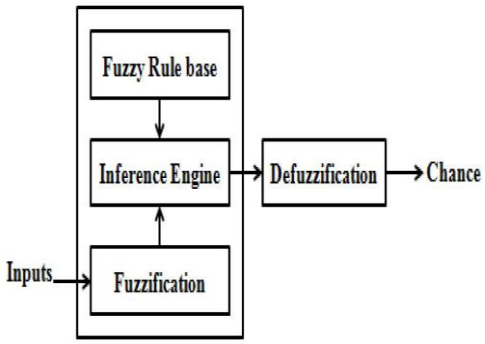
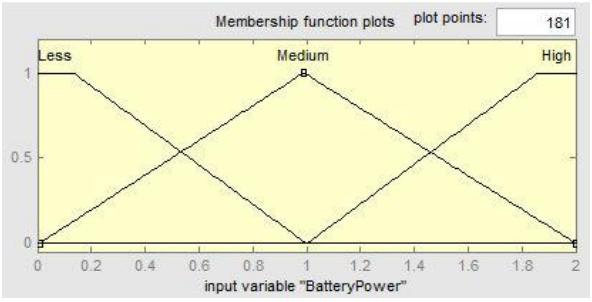


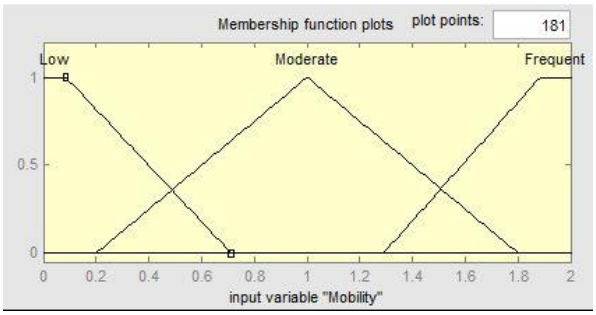
Fig. 2 Block diagram of Fuzzy Inference System.

For completion of the process, four steps are required given below:

1) Fuzzification: The inputs are disposed with crisp value and changed in to the fuzzy set in fuzzifier. Fuzzification is the first step in the fuzzy inference process. This includes a rule conversion where crisp inputs are converted in to fuzzy inputs. Crisp inputs are precise inputs measured by sensors and passed in to the control system for preparing such as temperature, pressure etc. In our propose protocol Mamdani's method Fuzzy inference technique is used to elect the Legitimate CHs and SCH. We have taken four Fuzzy input variables to elect appropriate CHs and SCH. All the four variables each have three membership functions plots in Figure 3. The fuzzy set that substitute the first input variable i.e. remaining battery power is illustrated in figure 3(a). The linguistic variables for the fuzzy set is less, medium and high. For less and high has been examined Trapezoidal membership function. The proposed protocol examines Base station as a mobile so the second fuzzy input variable is mobility of the base station. For mobility the linguistic variable are taken as low, moderate and frequent. The fuzzy set for mobility is illustrated in figure 3(b). The third fuzzy input variable is the centrality. The linguistic variables are centrality is examined as close, adequate and far. The fuzzy set for centrality is depicted in figure 3(c). The fourth fuzzy input variable is BS Route. The linguistic variables are BS Route is considered as ON, Off and Always. The fuzzy set for BS Route is illustrated in figure 3(d). The membership functions for input variables are used given in table 1.



(a)



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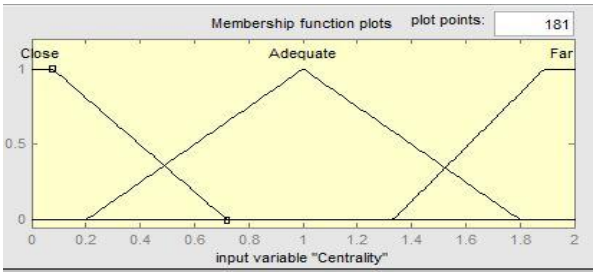
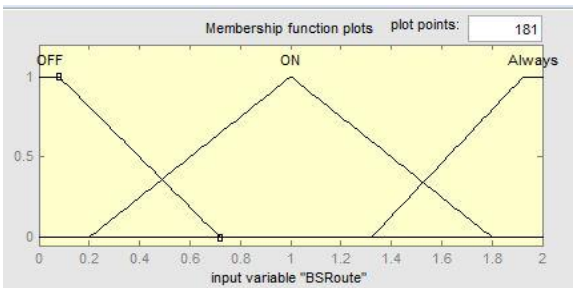


(c)



(d)

Fig. 3 Membership Function Plots. (a) Battery Power. (b) Mobility. (c) Centrality. (d) BS Route

Table 1 MEMBERSHIP FUNCTIONS FOR INPUT VARIABLES

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

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2) Rule Base and Inference Engine: It stores the IF-THEN rules. The fuzzy inference system (FIS) is a process that uses the 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 has been strongly enforced in fields such as automatic control, decision analysis, expert system and computer vision. In our system, we have 27 rule used in fuzzy interference. The rules in the form is if W,X,Y,Z then C. W means remaining battery power, X means mobility, Y means the centrality, Z means BS Route and C means the chance. The rules are imitative from the formula given in fuzzy equation 1.

Chance = (Battery Power – 1) + Mobility + Centrality + BS Route …… (1)

In this equation we have examined remaining battery power as (Battery Power – 1) because in each round there will be dissipate some energy at each node. So, after processing of each round, the remaining energy is examined for the next round. Mobility, Centrality and BS Route is considered to be preservative factor. The output chance possessed of 7 membership functions very weak, weak, lower medium, medium, higher medium, strong, very strong. For chance the fuzzy set is illustrated in Figure 4. The membership function for output variable chance is given in Table 2. The fuzzy rules and value of chance is depicted in Table 3.

3) Deffuzzification: It converts fuzzy set in to crisp value.

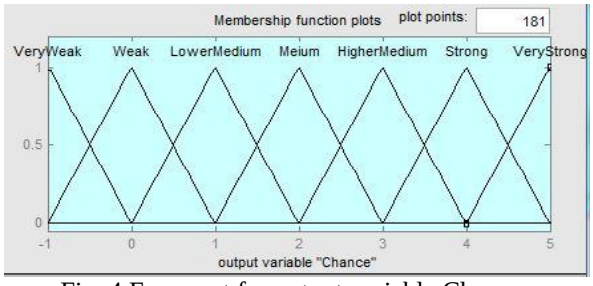

Fig. 4 Fuzzy set for output variable Chance.

Table2.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)

IV. SIMULATION RESULT AND ANALYSIS

In order to implement the proposed algorithm the communication and required parameters of interest are given in Table 3.

A. Experimental Setup: The concept of fuzzy logic is being implemented in MATLAB software. To compare the performance metrics of our interest with Leach with Fuzzy descriptors which ensure that the proposed protocol extended lifetime of the WSN. In this experiment, we have examined 200 nodes arranged randomly over the area between (x=0, y=0) and (x=100, y=100) with BS location (x=50, y=50).

Table: 3 SIMULATION PARAMETERS

Parameter	Value
Area(x,y)	100,100
Base station(x,y)	50,50
Nodes(n)	200
Probability(p)	0.1
Initial Energy(Eo)	0.5
transmiter_energy	50nJ/bit
receiver_energy	50nJ/bit
Free space(amplifier)	10nj/bit/m2
Emp	0.0013pJ/bit/m4
Packet Header size	25 bytes
Data packet size	6400
Message size	4000 bits
Node distribution	Random
Effective Data aggregation	5nJ/bit/signal

B. Result and Discussion: In this section, we prompt the experiment of results attained from the simulation to classify the proposed. The elect SCH among the CHs by fuzzy logic packet send to Base station. Figure 5 shows the packet sent to BS verses round. It represents the proposed protocol sent no. of packet more than existing algorithm.

Figure 6 shows the Faulty nodes versus round. The proposed algorithm represents the no. of faulty nodes less than existing. Energy of nodes verses round show in Figure 7. In proposed the energy of nodes is more than existing. Figure 8 shows the Network Lifetime. Overall network lifetime increase than existing.

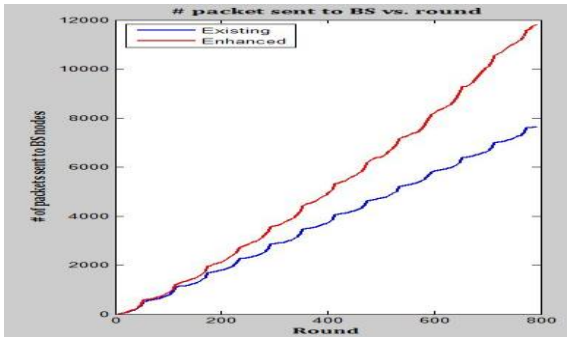

Fig. 5 Packet sent to BS vs. Round

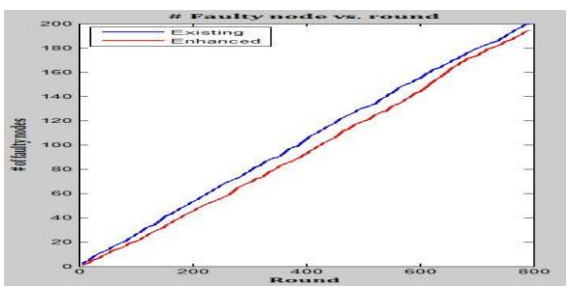

Fig. 6 Faulty nods vs. Round

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V. FUTURE WORK

Our future work involve the performance criterions such as First node Dies (FND), Half Node Alive (HNA), Last Node Dies (LND), End to end delay and Network stability by using matlab simulator. We can compare the performance criterions of our proposed protocol with Leach with Fuzzy descriptor protocol. The instinctive result of our proposed protocol announce that it can be higher energy effective than other protocols.

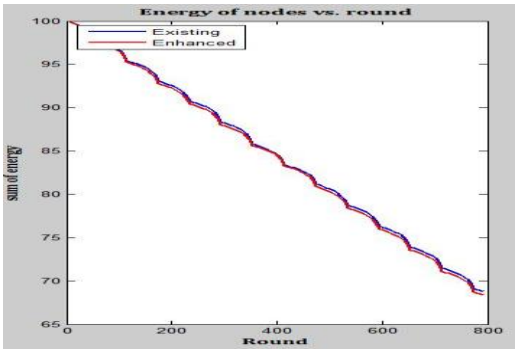

Fig.7 Energy of nodes vs. Round

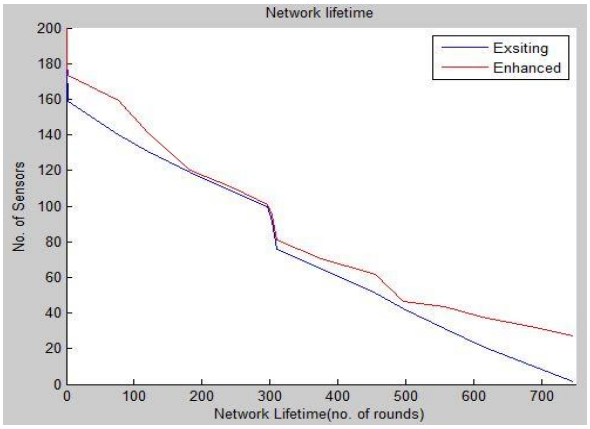

Fig. 8 Network Lifetime

VI. CONCLUSION

In this paper, for WSN an energy effective clustering algorithm has been proposed. The proposed protocol elected the CHs from clusters and one Super Cluster Head is elected among the Cluster Heads using fuzzy descriptors such as Remaining Battery power, Mobility, Centrality and BS Route, who is only responsible for delivering the message to a mobile Base station. Increase the network lifetime dramatically by the idea of sink Mobility along with the fuzzy logic. Simulation result shows that the proposed perform better than Leach with Fuzzy descriptors in terms of Packet sent verses round, Faulty nodes verses round, Energy of nodes verses round and better Network lifetime. The work is under progress.

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