

Energy Diminishing with Clustering Scheme using Fuzzy abiding Cluster Formation Protocol in Wireless Sensor Network

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Abstract

Life enhancing at all times had been one of the concentrating phases in Wireless Sensor Networks. Higher amount of energy is devastated during transmission process of data exchanging in between base station and sensor nodes. Data gathering is a familiar but critically operated in many applications of wireless sensor networks due to shortage of energy quantity. Modern techniques that progress energy efficiency to extend the network lifetime are extremely obligatory. Clustering being one among effective ways to lengthen life span due to its flexibility, reliability and scalability. In this paper, we propose a novel scheme Fuzzy abiding cluster formation protocol (FACFP) that make use of Mamdani's descriptors to successfully control data gathering applications. The proposed scheme considers: Energy, Concentration and Centrality in chorus to elect cluster head among nodes that make this approach energy efficient and more feasible. Simulation reveals projected scheme, curtail energy consumption and boost lifetime of network.

Keywords: Wireless sensor networks, cluster formation, Fuzzy logic, cluster head election, FIS.

I. INTRODUCTION

In the recent years, progress in Electronics and Wireless communications leads the developments of Wireless sensor networks [1]. Apiece sensor nodes is typically operational with transceiver that are compiled of small size, short cost and multifunctional sensor nodes that senses and mount up the information. Data so mounted is processed under sensing unit in ADC, further precede the data to base station via processing and communication units and lastly figure it out for the use in higher applications as shown in Figure 1. Wireless sensor networks not only converse with base station, but with all peer connections. The expansion of wireless sensor network was provoked via armed applications such as battlefield monitoring, machine health monitoring, and traffic routing and home automation.

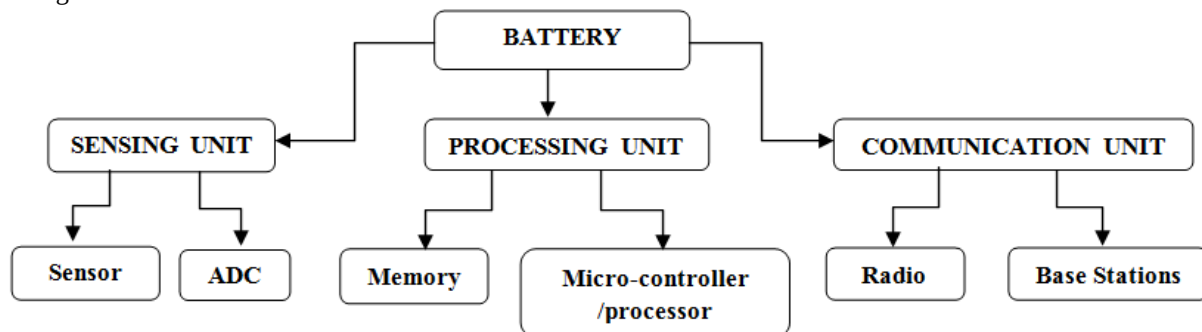


Fig 1. Structure of Sensor Nodes.

It is tough to plan WSN that can accomplish price economy and compact size of design. Node energy is the chief concern in scheming pattern because energy is devastated in conduction and by only replacing the battery is nowhere a solution to pact with this problem. With the superior algorithm like clustering, we can conquer better lifespan. Cluster based hierarchical routing protocol is energy efficient. In the procedure of clustering, sensor nodes are alienated in sets with a Head among each set. Cluster head congregates statistics from all the member nodes in all sets and process it to Base Station. This will radically trim down overall energy being devoted in transmission processes by allowing only heads to deal with Base Station [2].

II. PRIOR WORK

LEACH the renowned clustering algorithm and origin of many new researches [3] that aspire to extend the network lifetime in wireless sensor networks. Theoretically, operation of LEACH is structured into rounds: Set up and Steady phase. All nodes have

firm probability to be Head for each round. In set up phase, each node choose separately to be a Cluster Head or not and promote the information to neighbors with the decision depends on $t(n) = 0$ or 1 whereas in Steady phase, each Cluster Head sends node data to neighbor base station. LEACH is periodical, centralized and probabilistic. The foremost negative aspect of LEACH is the enlarged network energy expenditure due to being single hop communication. It was prepared on the hypothesis to be directly in contact with base station. The possibility of appearing head may have inaccuracy in having no Cluster Head or traffic of heads concurrently [4]. This procedure is made with the draw round decided on the threshold value; consequently node becomes Cluster Head for that specific round. Figuring $t(n)$ in the below equation

$$t(n) = \frac{P}{1 - p(r \bmod \frac{1}{p})} \text{ if } n \in G, \text{ otherwise } t(n) = 0 \dots \dots \dots (1.1)$$

P symbolizes the percentage of cluster heads expected;

r characterizes the number of rounds;

G is set of nodes yet not elected as cluster head.

Gupta [5] illustrates the selection of cluster heads with fuzzy logic using three erratic: Energy, Concentration of nodes and centrality of a node. He partitioned each individual erratic in three varying levels: low, high and medium and practically operate it on LEACH. The single divergence lies in these two protocols were in their set-up phases; where base station mounts up the statics of energy level and site for each node, evaluate it with FIS to explore the chance for node to appear as Cluster head. Base station firms up the node that get maximum chance to be a cluster head.

CHEF(cluster head election mechanism using fuzzy logic in wireless sensor networks) [6] protocol was equivalent to Gupta's protocol that augments the duration of nodes using fuzzy logic with localized cluster head mechanism while Gupta's protocol need no information regarding nodes from BS.

LEACH-FL (improving on LEACH protocol of wireless sensor networks using fuzzy logic) [7] implement fuzzy logic to advance LEACH protocol on three aspects: energy, node density and distance between CH and BS. This was similar to Gupta's apart from the set-up stage make a choice of different parameters to relate FIS to accomplish probability for each node.

The above discussion demonstrates number of variations on LEACH protocol that make use of fuzzy logic [6] [7] [8]. Our proposed algorithm FACFP uses fuzzy logic for cluster formation; conversely other protocols use it for CH selection.

III. FUZZY ABIDING CLUSTER HEAD FORMATION PROTOCOL WITH FIS

Our proposed algorithm targets to acquire superior lifetime of wireless system via planned FIS system that represents the technique to derive the mapping of input to output. It drives similar as LEACH and only oscillates in cluster formation phase. Our proposed protocol FACFP errands to be a cluster head for the non Cluster head's among nodes. [9]

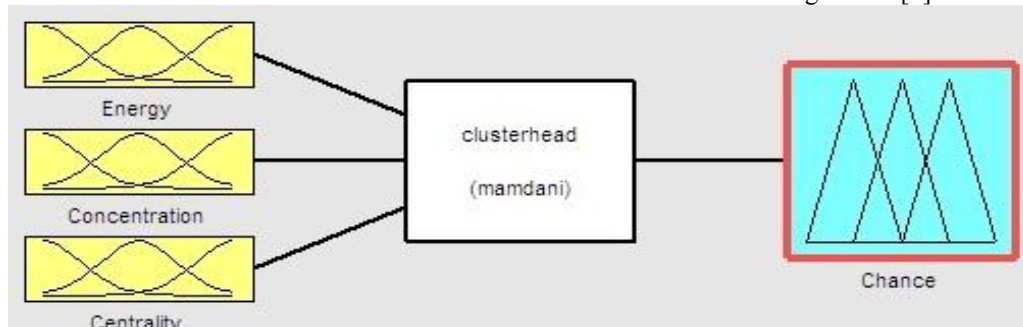


Fig 1. building FACP protocol with FIS system

A. FIS factors and laws

FACFP is operated with the use of radio model to figure the energy being dedicated during transmission and reception of data between transmitter and receiver.[9]

$$E = E(tx) + E(rx) \dots (1.2)$$

$$\text{Where } E(tx(k, d)) = E(elec) * k + \varepsilon(amp) * K * d^\lambda \dots (1.3)$$

$$E(rx(k, d)) = E(elec) * k \dots (1.4)$$

Hereby, **d** symbolize distance between transmitter and receiver of the network;

E(tx) = transmitted energy; **E(rx)** = the received energy; **E(elec)** = the electronics energy;

ε(amp) = the energy constant for propagation; **λ** = path loss exponent.

To expand and acknowledge the network lifetime in MATLAB fuzzy logic toolbox, we divide each one linguistic erratic: ENERGY and CONCENTRATION as Low and High varying points with trapezoid membership function and Medium with triangular membership function and CENTRALITY of nodes as Close and Adequate varying points with trapezoid membership function and Far with Triangular membership function and are revealed in Figure 1, 2 and 3 respectively.

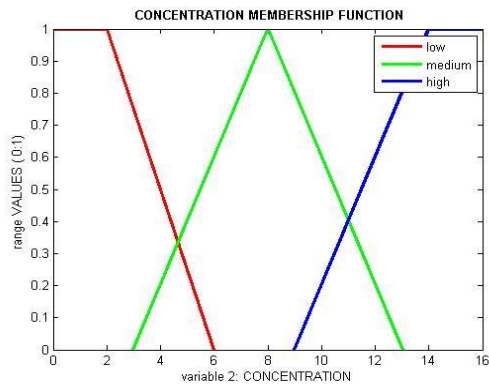


Fig.1 MF of ENERGY

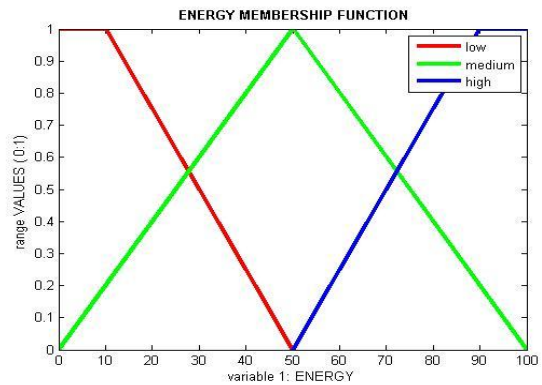


Fig.2 MF of CONCENTRATION

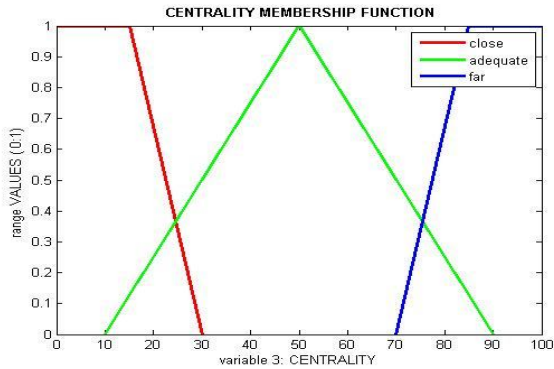


Fig.3 MF of CENTRALITY

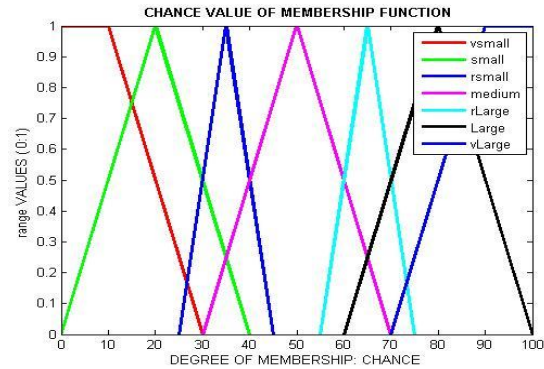


Fig.4 MF of Chance value

To confer the proposed protocol characteristic lithely and supply, we divide linguistic erratic Chance in 7 levels as: very small, small, rather small, medium, rather large, large and very large. We symbolize very small and very large with trapezoid membership function and the rest with triangular membership function as shown in Figure 4. The algorithm used to construct FACFP is discussed in Algorithm1.

CH: Cluster head

CM: Cluster member

CM-m: Cluster member message

CH(b): Chance of CM to be CH

b: node of cluster in a network

C: {c| c is b's neighbor}

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1.  if chance(b) ← fuzzylogic (Energy, centrality, concentration);
2.    advertise (chance(b),C);
3.    receive Chance value C;
4.  else
5.    for (chance(b) > chance(c) )
6.      CH(b) ← b ;
7.    end
8.  if (CH(b) == true)
9.    advertise (CM-m, C)
10.   receiving JOIN-REQ-m;
11.   ACK: send to CH to connect with b.
12.   Data packets- each CM;
13. else
14.   receiving CM-m;
15.   JOIN-REQ-m : send to the nearest CH;
16. end
17. end
18. Data transmission over shortest path
19. End of process
    
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Algorithm 1: The proposed FACFP protocol

Considerable two intense cases with If-Then rule are measured from Table 1.

Intense case 1: If (energy = low), (conc. = low) and (cen. = far) then (chance = very small)

Intense case 2: If (energy = high), (conc.= high) and (cen. = close) **then** (chance = very large)

Table - 1
FIS If-then rules

Energy	Conc.	Centrality	Chance	Energy	Conc.	Centrality	Chance
Low	Low	Close	Small	Medium	Medium	Far	Small
Low	Low	Adequate	Small	Medium	High	Close	Large
Low	Low	Far	vSmall	Medium	High	Adequate	Rlarge
Low	Medium	Close	Small	Medium	High	Far	Rsmall
Low	Medium	Adequate	Small	High	Low	Close	Rlarge
Low	Medium	Far	Small	High	Low	Adequate	Medium
Low	High	Close	Rsmall	High	Low	Far	Rsmall
Low	High	Adequate	Small	High	Medium	Close	Large
Low	High	Far	vSmall	High	Medium	Adequate	Rlarge
Low Medium	Low	Close	Rlarge	High	Medium	Far	Medium
Medium	Low	Adequate	Medium	High	High	Close	vLarge
Medium	Low	Far	Small	High	High	Adequate	Rlarge
Medium	Medium	Close	Large	High	High	Far	Medium
Medium	Medium	Adequate	Medium				

B. Creating Cluster Head chance value

The illustration of fuzzy logic follows four steps: Fuzzification, Rule evaluation, Aggregation and Defuzzification [9]. These steps are drawn in our designed FIS system of MATLAB to outline the chance value as:

- (1) Fuzzification: forwarding of inputs: energy, concentration and centrality of nodes to FIS are firstly done through this. Depending on these crisp values, membership value is persistent.
- (2) Rule valuation: Followed by Fuzzification the next step is to establish rules. We endow membership value conquered for if-then rule to formulate new fuzzy output sets. Our proposed fuzzy protocol have multiple inputs for if-then rules, a fuzzy operator opt least of three membership values to get single figure.
- (3) Aggregation: Aggregation bring together all output values dogged from the rules with OR fuzzy operator and applies equation 1.5 to estimate the energy of a node. Concentration and centrality of nodes is formulated via distance formula in 1.6.

$$Ne = \frac{E(\text{remaining})}{E(\text{total})} \dots (1.5), \quad \text{Where } Ne = \text{node energy}$$

$$Do = \sqrt{((x2 - x1) - (y2 - y1))^2} \dots (1.6), \quad \text{Where } D \text{ is distance among X and Y nodes.}$$

- (4) Defuzzification: Prior phase is Defuzzification where we bring out our chance value. We take advantage of Mamdani method to deem implication value and centroid Defuzzification to establish cluster head election chance value to outline a cluster formation. By employing the values of aggregated data in appropriate ways we can approximate the chance of node to be a Cluster head among individual cluster. If more than two cluster head attains same chance value, the opportunity is given on the basis of energy of node, centrality and distance nearer to Base station to decide for the fittest outcome for survival.

C. Valuation

Using the planned model, it sanctions lifetime of a network metric to compute data collection rounds till FND i.e. the very first node that shed energy similar as discovered in prose is declared to be first node dead [10][11]. The foundation of practical model of our research has recognized is shown in the Table 2.

Table - 2
Simulation parameters

Type	Parameters	Value
Network topology for Part1.	No. of nodes for both parts Area of deployment Expected clusters Base Station position	100 200m*200m 5 100m,160m
Network topology for Part2.	Area of deployment Expected clusters Base Station position	10m*10m 9 3.5m, 12m

Simulation configuration	Startup energy(E_0)	0.5 J
	E (initial energy)	100J
	Simulation rounds	5000
	Energy deduction	0.5

IV. Simulation scenario

To evaluate the performance of both LEACH and FACFP we firstly present the random deployment along with CH formation of both protocols in Figure 5, 6. Figure 5 is plotted with random nodes deployment and probabilistic selection of nodes whereas in Figure 6 same numbers of nodes are deployed randomly and follows fuzzy rule to elected heads in different area.

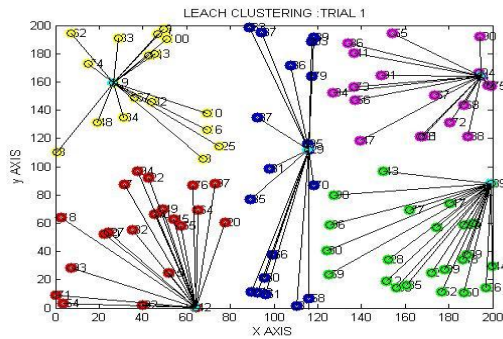


Fig 5. LEACH

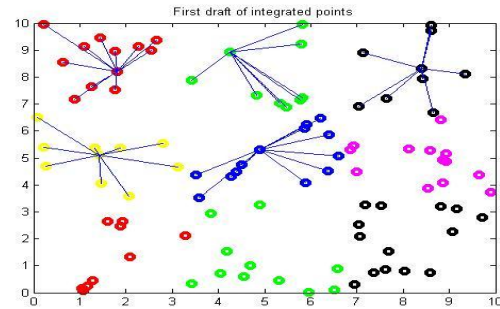


Fig 6. FACFP

Figure 7 and 8 is the demonstration of FND (First node dies) for both LEACH and our FACFP algorithms are represented for two trials. Correspondingly Figure 9 and 10 is the demonstration of HNA (Half node alive) for both LEACH and our FACFP algorithms for two trials. FACFP outperforms the LEACH algorithm on the basis of inspection of the values of FND and HNA in LEACH and FACFP, appraises in the Table 3. These development lies on the character and number of factors that have been worn in carrying out the tests for each protocol.

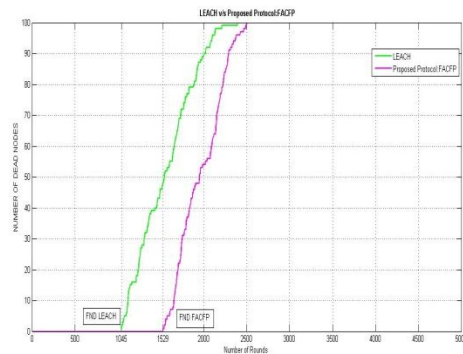


Fig 7. FND for trial 1

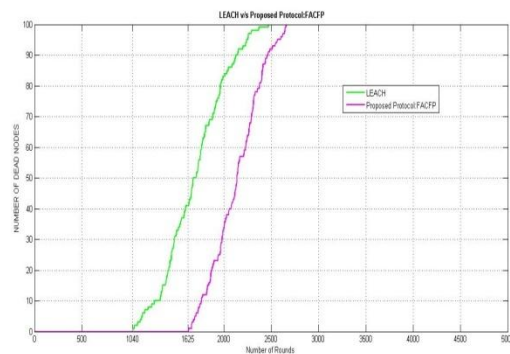


Fig 8. FND for trial 2

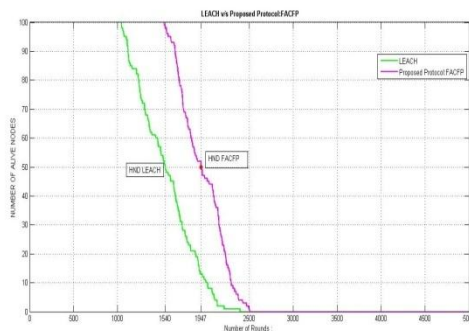


Fig 9. HNA for trial 1

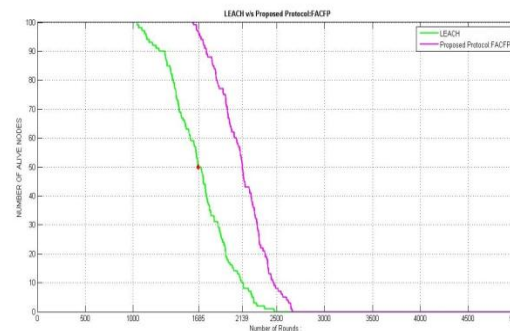


Fig 10. HNA for trial 2

Table - 3
FND and HNA for LEACH and FACFP

Trails	LEACH		FACFP	
	FND	HNA	FND	HNA
1	1045	1540	1529	1947
2	1040	1685	1625	2139

From the foregoing examination and analysis we drape that FACFP spice up time for FND nearly 10.69% and HNA 8.61% than LEACH; as it is reflected on three factors for cluster formation: energy, centrality and concentration analogous in [5] to assess the chance value for being a cluster head rather than one as LEACH.

V. CONCLUSION

In this paper, we perform our planned scheme for cluster formation in wireless sensor networks that formed on the foundation of fuzzy logic to enlarge network lifetime as energy consumption and drainage serves the scarcest source for designing WSN. We have investigated and simulated the presentation of our protocol and evaluate against LEACH, to acquire energy efficiency, minimize the energy practices and accordingly will have enlargement in the WSN lifetime. We have considered stationary sensor nodes for our planned protocol. Additionally, my work stands on fuzzy sets and compared the proposed planned work with other clustering algorithm.

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