A survey of cluster head selection using efficient optimization algorithms in wireless senor networks

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Abstract: Wireless Sensor Networks (WSNs) are a system of expansive number of remote sensor nodes sent over a wide topographical territory. The sensor nodes have a constrained measure of memory just as power. Clustering observed to be a powerful procedure to take care of the vitality utilization issue for WSN by staying away from long separation correspondence. In WSN, sensor node's life is a basic parameter. Research on life expansion depends on Low-Energy Adaptive Clustering Hierarchy (LEACH) plot, which turns Cluster Head (CH) among sensor nodes to disseminate energy utilization overall system nodes. CH choice in WSN influences arrange vitality productivity incredibly. This paper displays a Literature overview of the calculations clarifying the ideas in particular cluster head election with hexagonal node deployment (CEHND), k-means particle swarm optimization (KPSO), k-means genetic algorithm (KGA), fuzzy and ant colony optimization based mac/routing cross layer (FAMACRO), and soft computing based cluster head selection (SCCHS) for cluster head choice in WSN. Different routing calculations have been considered by authors to enhance the energy efficiency, network lifetime, packet delivery ratio.

Keywords: WSN, Clustering algorithms, Optimization algorithms, Cluster-head, Fuzzy logic, Node deployment.

I. Introduction

Wireless sensor systems are another age of ongoing systems which incorporates huge number of sensor node gadgets dissipated over an expansive field. Wireless sensor systems are utilized in armed force, cleanliness, industry, instruction, horticulture. Sensor nodes by and large are fueled by little batteries that are difficult to supplant or energize. Subsequently vitality requirement is a noteworthy test for wide and remote applications. A large portion of the vitality utilization in the system is because of the data transference inside the system. In this way, it winds up critical to improve the vitality utilization and deal with the power devoured by the sensor nodes.

In LEACH convention [1], cluster heads are picked first and after that the individuals from each cluster head are resolved. Cluster individuals send the got information to group make a beeline for TDMA scheduler. Group head joins the got information and sends it to base station.

Wireless sensors (nodes) in the system sense outer information from the encompassing condition, process the detected information locally, and afterward send the information to a base station for further preparing through remote correspondence, for the most part radio recurrence (RF). Every node is outfitted with a battery that has constrained lifetime. A large portion of the node's vitality is expended amid correspondence [2]. The expended vitality amid correspondence is influenced exponentially by the separation between the conveying nodes; the more correspondence separate between two nodes the more vitality expended. WSNs are extremely touchy to vitality utilization and its execution relies upon the system lifetime. The system lifetime means that the system debasement; the demise of one node is before long prevailing by death of others and nodes separation. In this manner, overseeing energy utilization is an essential errand in WSN execution.

Routing decides a way between source node and sink (goal) node amid information transmission. In WSNs, a system layer actualizes approaching information directing. For the most part in multi-jump arranges a source node can't achieve a sink specifically. In this way, middle of the road sensor nodes hand-off on packets. Routing table usage is the arrangement. They have arrangements of node choices for any packet destination. Routing table is a routing calculation undertaking supported by a directing convention for development/upkeep [3]. Directing ways are built up through Proactive, Reactive or Hybrid ways. Proactive conventions process courses before need and store them in a node's Routing table. Receptive conventions process routes just when it is required. Hybrid protocols consolidate both the thoughts [4].

II. Related work

In [5], author proposed In Unequal clustering calculation for WSN dependent on fuzzy rationale and enhanced ACO, the conditional cluster heads are chosen by considering data held by each sensor node locally, for example, introductory vitality of the node, separate between the node and the base station and nearby thickness. Fuzzy rationale framework is utilized to decide one node's possibility of getting to be cluster head and estimate the relating fitness sweep.

In [6], author proposed Sensor nodes are conveyed at the focal point of every phone guaranteeing legitimate inclusion of the system. The hand-off nodes are put all through the system zone with an objective to guarantee availability.

In [7,8], author proposed WSN comprises of spatially appropriated independent sensor nodes. The sensor nodes research the encompassing condition and send the recorded information to an exceptionally processed station, called sink. The sink is in charge of gathering and preparing the information got from the nodes.

In [9,10], author proposed Several various leveled clustering conventions have been proposed for energy effective information assembling in WSN5. Hybrid Energy Efficient and Distributed (HEED) intermittently chooses cluster heads dependent on a hybrid of two node parameters: leftover vitality to choose an underlying arrangement of cluster heads and intra-group correspondence cost for definite set. This enhances energy effectiveness of HEED yet its clustering procedure requires a few emphases and a great deal of control packets are communicated in every emphasis. Distributed Energy Efficient Hierarchical Clustering (DWEHC) clustering convention constructs staggered groups with a cluster head with its first dimension youngster, second dimension kid, etc.

In [11], author proposed A WSN sensor discusses specifically with different sensors inside radio range in a group. Many bunching calculations like LEACH, DEEC, and SEP were proposed with the points of route path determination, vitality minimization, expanded availability and system life span. The issues of cluster arrangement and CH choice between various conventions for data aggregation and transmission were analyzed.

III. Cluster Head Election with Hexagonal Node Deployment Technique in Wireless Sensor Networks

Tripti Sharma, G.S.Tomar, Ishaan Berry, Aarti Kapoor and Suhani Jasuja [12], the author presented that the limitations of LEACH protocol have been overcome using the fuzzy logic and the hexagonal homogenous deployment.

A. Energy Model Analysis

The energy scattering model as utilized in the proposed methodology is appeared in Figure 1. Every sensor node comprises of a transmitter and beneficiary having some transmitter and collector hardware. Energy is dispersed when hubs transmit and get information.

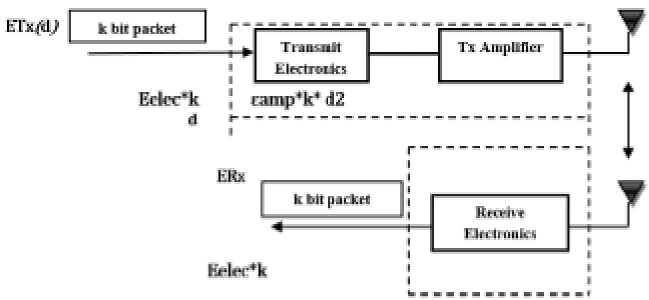

Fig1: Energy dissipation diagram

When the sensor nodes transmit k-bit data by its transmitter, the energy dissipation is shown in equation 1:

$ET(k,d) = (Eelec * k) + \left(E_{fs} * k * d^2\right)\ if\ d <=$
$(E_{elec} * k) + \left(E_{fs} * k * d^4\right)\ if\ d > d_0$ (1)

- Eelec is the energy dissipated to run the electronics circuits
- k is the packet size
- Efs and Emp are the characteristics of the transmitter amplifier
- d is the distance between the two communicating ends.

When the sensor node receives k-bit data packet, the energy dissipation is represented in equation 2.

$ER(k) = Eelec * k$ (2)

The radio characteristics and energy due to electronics are:

- Eelec = 50 nJ/bit
- Efs = 10 pJ/bit/m2
- Emp = 0.0013pJ/bit/m4

In addition to above energy dispersals, CHs additionally disseminates vitality in data aggregation. The data aggregation vitality EDA has the estimation of 5nJ/piece/flag.

B. Fuzzy Model

The model of fuzzy rationale control comprises of a fuzzifier, fuzzy rules, fuzzy surmising motor, and a defuzzifier [13]. The fresh information is changed over into fuzzy sets by the fuzzifier. At that point rules are connected on the fuzzy sets to deliver a yield in type of a fuzzy set. The defuzzifier then converts the yield fuzzy set to fresh yield utilizing one of the numerous defuzzification procedures [14].

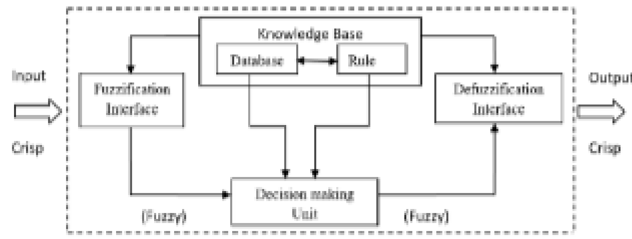

Fig2: Fuzzy system

A Fuzzy system basically consists of three parts and represented in figure 2:

(1) Fuzzifier: The fuzzifier maps each fresh information incentive to the comparing fuzzy sets and hence doles out it a reality esteem or level of participation for each fuzzy set.

(2) The surmising motor procedures the fuzzified values, which comprises of a standard base and different techniques for deducing the guidelines. The standard base is just a progression of IF-THEN decides that relate the information fuzzy factors with the yield fuzzy factors portrayed by administrators AND, OR and so forth [15].

(3) Defuzzification: The way toward creating a quantifiable outcome from fuzzy sets and relating participation degrees [16].

We use LEACH protocol as basis for transmitting data from the sensor node to the base station. Algorithm followed in implementing this approach is given below figure 3:

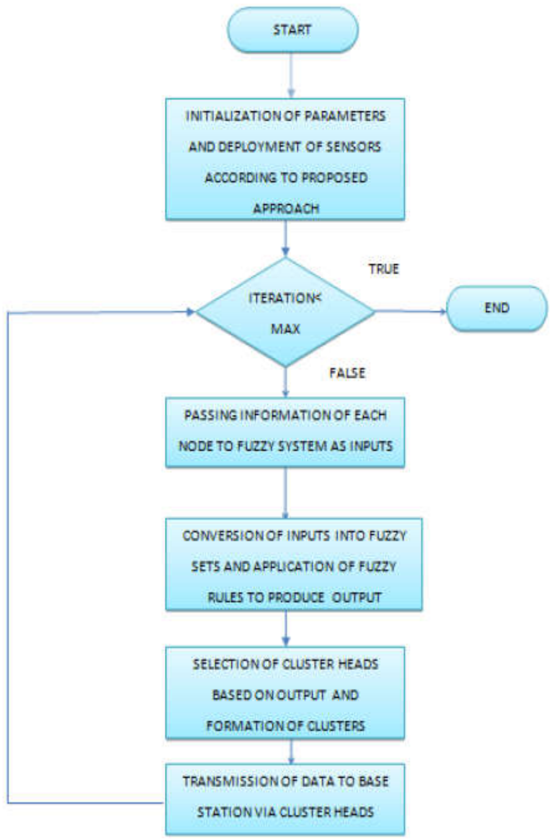

Figure 3.Flow Chart of Advanced LEACH Approach

1. **Sensor Initialization**: All the sensor nodes are initialized with an initial energy E_o.

2. **Sensor Deployment**: The sensors are deployed hexagonally to increase the sensing area and to minimize the redundant data.

3. **Fuzzification**: The crisp input data consisting of energy and distance of node from base station is converted to fuzzy sets.

4. **Application of fuzzy rules**: Fuzzy rules are applied to the fuzzy sets and the fuzzy outputs are formed.

5. **Defuzzification:** The fuzzy sets are converted into classical sets by applying Centroid defuzzification technique.

6**. Cluster Head Selection**: Cluster heads are selected as per the value of the output from the fuzzy inference system.

7. **Cluster Formation**: Clusters are formed surrounding the cluster heads and data is then transferred to the base station via the cluster heads.

IV. Evaluation of Hybrid K-Means Clustering Algorithm for Wireless Sensor Network Using PSO and GAs

Alaa Sheta and Basma Solaiman [17] the author presented a hybrid K-means PSO/Gas clustering algorithm. Both the KPSO and KGAs shall be used to define the sensors belonging to each cluster and the best CHs.

A. Genetic Algorithms

Hereditary calculations (GAs) are versatile pursuit calculation which were displayed by J. Holland [18], and widely examined by Goldberg [19, 20], DeJong [21, 22, 23], and others. GAs effectively dealt with numerous zones of utilizations and could comprehend a wide variety of troublesome numerical enhancement issues. Gas requires no angle data and is significantly less liable to get caught in neighbourhood minima on multi-modular hunt spaces. GAs observed to be very inhumane to the nearness of clamor [24]. The pseudo code of the GAs strategy [19, 20] is appeared in Algorithm 1.

Utilizing GAs, the issue is encoded into chromosomes speaking to conceivable arrangements. A wellness work is utilized to explore the nature of every person in the populace. The people in a populace experience hybrid and transformation to create the people to come.

Algorithm 1: Basic steps of GAs

1 begin GAs
2 $g = 0$ generation counter
3 Initialize population
4 Compute fitness for population $P(g)$
5 **While** (Terminating condition is not reached) do
6 $g = g + 1$
7 Select $P(g)$ from $P(g - 1)$
8 Crossover $P(g)$
9 Mutate $P(g)$
10 Evaluate $P(g)$

end while
end GA

B. Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a populace based pursuit calculation, with particles speaking to conceivable arrangements. The particles move in the inquiry space, speak with their neighbourhood's, and utilize a wellness capacity to recognize their next area in the pursuit space. The PSO particles iteratively refresh their speeds and positions until the point when they combine into a conceivable ideal arrangement. The fundamental PSO calculation is appeared in Algorithm 2. A proficient vitality the board of the WSNs based PSO was given in [25].

Algorithm 2: Basic steps of PSO
begin
Randomly initialize the position and velocity of
the particles: *Xi*(0) and *Vi*(0)
While (Terminating condition is not reached) do
for *i* = 1 to number of particles
Evaluate the fitness:= *f* (*Xi*)
Update *pi* and *gi*
Update velocity of the particle *Vi*
Update position of the particle *Xi*
Evaluate the population fitness
Next for
end while
end PSO

V. FAMACRO: Fuzzy and Ant Colony Optimization based MAC/Routing Cross-layer Protocol

Sachin Gajjar, Mohanchur Sarkar, Kankar Dasgupta [26] the author exhibited that FAMACRO, a cross-layer convention that joins thoughts of energy effective various leveled cluster routing and media get to. It utilizes a fuzzy based cluster head choice system for choosing nodes with high excessively vitality, having increasingly number of neighboring nodes and high caliber of correspondence connect. One of the issues of various levelled grouping is "problem areas" issue which emerges because of substantial hand-off traffic for cluster head goes to MS making them bite the dust prior. This prompts genuine availability and inclusion issues in zone near the MS. To conquer this issue, FAMACRO arranges the system into groups of unequal sizes with clusters nearer to MS having littler sizes than those a long way from it. Therefore, cluster heads close MS will have less measure of intra-cluster traffic safeguarding their vitality for between cluster hand-off traffic. At last, for solid and vitality proficient information exchange to MS, FAMACRO utilizes ACO system for between group directing from cluster heads to MS. It chooses hand-off cluster head which is: having high leftover vitality and packets gathering rate; is close to current cluster head (to decrease inter-cluster transmission vitality); is close to MS (to decrease vitality to transmit information to MS).

A. FAMACRO operation

The operation of FAMACRO consists of network setup and steady-state phase.

5.1. Network setup

Amid this stage nodes in the system are composed into "layers" as depicted in the means underneath.

Stage 1: MS sends SETUP_MSG message (containing its ID, (x, y) area co-ordinates, timing data to synchronize nodes' timekeepers, transmitting power data PMSt) with flag quality sufficiently substantial to reach Rmax m (most extreme transmission scope of node).

Step 2: Every node evaluates its separation from MS utilizing two-beam ground radio engendering model as given below equation 3,

$$dis(i) = \sqrt[4]{\frac{P_{MSt}G_{MSt}G_{ir}h_{MSt}^2h_{ir}^2}{P_{ir}L}} \qquad (3)$$

Where P_{MSt} and P_{ir} is power, G_{MSt} and G_{ir} is gain, h_{MSt} and h_{ir} is height above ground for MS transmitting antenna and node *i* receiving antenna respectively. L is path loss. Each node uses the calculated distance to find its layer as discussed next. The first layer is a circular ring with centre at MS and radius as *Rmax* m. The second layer is a circular ring with centre at MS, outer radius of *Rmax* x 2 m and inner radius of *Rmax* x (2-1) m. In general, each N_{th} layer is a concentric circle with centre as MS, outer radius of *Rmax* x *N* m and inner radius of *Rmax* x *(N-1)* m.

Stages 1 and 2 are then rehashed and in every emphasis, MS expands flag quality of SETUP_MSG to reach Back to back layers. This is proceed with d until the point that whole detecting field is secured and in this manner every node knows its layer. Every node at that point utilizes a non-diligent CSMA MAC convention to communicate a HELLO_MSG message (containing its ID, layer number, area) with flag quality sufficiently substantial to achieve every single neighbouring hub in its layer.

5.2. Steady-state

It is partitioned into rounds comprising of cluster head determination, clustering and information conveyance to MS.

• Cluster Head Selection: Nodes settle on free choices for getting to be cluster heads utilizing Fuzzy Inference System (FIS) with Mamdani demonstrate. FIS structure for group head is talked about straightaway.

• Input factors for FIS

• Residual energy (spoken to by ENERGY): It is vitality staying in the node. To end up a cluster head, a node ought to have more ENERGY contrasted with its neighbouring nodes.

· Node's neighbourhood nearness (represented by NBR_NR): NBR_NR(x) of a node *x* is defined as in equation 4,

$$NBR\_NR(x) = \frac{1}{N_{TR}}\left(\sum_{y=1}^{y=N_{TR}-1} d(x,y)\right) \quad (4)$$

Where N_{TR} is total number of nodes within transmission range and layer of *x*, *d(x, y)* is distance between node *x* and *y*.

To become a cluster head, node should have more nodes in its transmission range to decrease intra-cluster communication cost and consequently should have a lesser value of NBR_NR.

VI. Soft Computing Based Cluster Head Selection in Wireless Sensor Network Using Bacterial Foraging Optimization Algorithm

Rajagopal, S. Somasundaram, B. Sowmya, T. Suguna [27], the author presented that an improved CH selection for efficient sensor network data aggregation. This new algorithm is based on BFO incorporated in LEACH.

A. A. Low Energy Adaptive Clustering Hierarchy (LEACH)

Filter by [28] is a popular clustering protocol that is the reason for some clustering conventions. The point of LEACH's is to have CHs diminish the energy cost of transmitting information from typical nodes to inaccessible Base Stations [29]. The LEACH task is partitioned into a Setup Phase and a Steady state stage. Each round starts with a set-up (clustering) stage where groups are sorted out, trailed by an unfaltering – state (transmission) stage where information bundles are exchanged from nodes to CHs. After information conglomeration, CHs transmit messages to a Base Station. In Setup Phase, a node chooses whether to wind up a cluster head toward the current round. The cluster head decision is finished with a likelihood work: a node chooses an irregular number somewhere in the range of 0 and 1 which if not exactly T(n), chooses the hub as a group set out toward current round appeared in condition 5:

$$T(n) = \begin{cases} \frac{p}{1-p(r \bmod \frac{1}{p})} & if\ n \in G \\ 0 & otherwise \end{cases} \quad (5)$$

Where, P is cluster head probability, r is a number of current round and G a set of nodes that have not been CHs in last 1/p rounds. After the CH election, every CH prepares a Time Division Multiple Access

(TDMA) schedule and transmits it to all nodes in their cluster. This completes LEACH's set up phase.

B. Bacterial Foraging Optimization (BFO)

BFO is another class of naturally empowered, stochastic, worldwide inquiry system impersonating E. coli microscopic organisms' searching conduct. This strategy finds handles and ingests sustenance. Amid scavenging, a bacterium shows tumbling or swimming activities [30].

Chemotaxis development proceeds till a bacterium achieves a positive-supplement slope. After explicit swims, the populace's best half experiences generation dispensing with others. A disposal scattering occasion guarantees nearby optima escape, where a few microbes are sold arbitrarily with a little likelihood and new substitutions introduced aimlessly hunt space areas.

VII. Comparison of Efficient Optimization algorithms in WSN

S.NO	Author	Title	Analysis
1.	Sharma, T., Tomar, G. S., Berry, I., Kapoor, A., and Jasuja, S. (2016).	'Cluster Head Election with Hexagonal Node Deployment Technique in Wireless Sensor Networks.'	Number of data packets transmitted to base station, energy consumption and prolonged network lifetime.
2.	Sheta, A., and Solaiman, B. (2015).	'Evolving a Hybrid K-Means Clustering Algorithm for Wireless Sensor Network Using PSO and GAs.'	Increasing the network lifetime means increasing the number of data samples taken from the region of interest.
3.	Gajjar, S., Sarkar, M., and Dasgupta, K. (2015).	'FAMACRO: Fuzzy and ant colony optimization based MAC/routing cross-layer protocol for wireless sensor networks.'	Energy-efficient, Reliable, and Scalable.
4.	Rajagopal, A., Somasundaram, S., Sowmya, B. and Suguna, T. (2015).	'Soft computing based Cluster Head Selection in Wireless Sensor Network using Bacterial Foraging Optimization Algorithm.'	Improve cluster head selection for efficient sensor networks data aggregation, Average End to End Delay (sec), Average packet drop ratio, and Lifetime Computation.

VIII. Conclusion

The applications and node plan of WSN requests a vitality proficient, solid, versatile yet basic WSN convention stack. LEACH chooses too numerous CHs at once or arbitrarily chooses CHs a long way from a base station without thinking about nodes' residual energy. Subsequently, some cluster heads deplete vitality early in this way diminishing the WSN's life. This paper examines about various cluster head choice instrument utilizing enhancement techniques. These calculations appears and speaks to better execution regarding packet delivery ratio, energy consumption, network lifetime.

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