Efficient Clustering using Fuzzy Logic in the Wireless Sensor Networks

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Abstract: In Wireless Sensor Networks (WSNs), power efficiency is one of the most essential factors influencing the networks' performance. Through a properly designed routing set of rules, WSNs' energy performance may be advanced evidently. Among diverse routing algorithms, hierarchical routing algorithms have blessings in improving nets' robustness and flexibility, and it's miles more appropriate for large scale of networks. In this paper, a few standard hierarchical routing algorithms are delivered, and their blessings and defects are analyzed. Based on these analyses, a brand new hierarchical routing set of rules with excessive electricity efficiency named EESSC is proposed that is based at the advanced HAC clustering method. In EESSC, the sensor nodes' residual electricity could be taken into consideration in clustering operation, and a unique packet head is described to help replace nodes' strength statistics whilst transmitting message the various nodes. When the clusters had been formed, the nodes in cluster might be arrayed in a list and cluster head would be rotated automatically with the aid of the order of listing. And a re-cluster mechanism is designed to dynamic alter the result of clustering to make sensor nodes corporation greater affordable. At final, EESSC is compared to different normal hierarchical routing algorithms in a sequence of experiments, and the experiments' result which proves that EESSC has manifestly stepped forward the WSNs' power efficiency has been analyzed.

Keywords: Clustering, EESSC, HAC, WSNs

1. Introduction:

A sensor node in a Wireless Sensor Networks (WSNs) is usually equipped with a transducer, a radio transceiver, small micro-controller and a energy supply (generally batteries)deployed in phenomenon supposed to display situations and parameters at diverse locations. Sensor nodes are capable of sensing many sorts of information from the environment inclusive of temperature, mild, humidity, pressure, wind direction and so on. They usually transmit the received records via RF (Radio Frequency) channel to the base station or Gateway. Recently, WSNs has been used and implemented for a extensive variety of software regions which includes – industrial process tracking &control and far flung manipulate, environmental monitoring, habit at monitoring, fitness care applications, home automation, item tracking, site visitors control and lots of other civilian and defense programs. However, WSN has its very own set of problems and constraints referring to layout obstacles and resource necessities in practices. Resource constraints encompass a restrained availability of valuable resource commonly

a) Energy
b) Range of Communication
c)Bandwidth
d) Processing Power
e) Storage Capacity

The latest studies in WSNs intend to conquer those constraints by means of introducing new layout principles, developing new or enhancing current protocols, building new applications, and growing new algorithms. Researchers are currently engaged in growing schemes so that it will finally accomplish these necessities of WSN. One of the largest troubles in WSN's is electricity intake. This desires to be carefully examined and researched for its intake styles at every respective sensor node of the network to facilitate the improvements and constructing appropriate algorithm to reap finest power intake and maximize the network lifetime. Typically the sensor nodes are powered by using small batteries which can be able to storing only limited electricity to provide for a completely short period. Generally, the sensors nodes are deployed in far flung areas usually left unattended. In such situation externally feeding or replenishing electricity to the battery and changing batteries is hard or not viable frequently. Therefore, prolonging the network lifetime with given energy by means of the preliminary battery supply in conjunction with the community, is an important optimization intention in this issue. Hence the energy consumption by way of whole community in each thing may be minimized. The viable answer to lessen energy consumption can also lie in power conscious network that is designed in one of these manner that each layer of the device is strategically used. Energy in the sensor nodes fulfills a totally crucial venture of real-time at are cording from the sensors. Therefore this studies is directed onwards is at the lines of– 'how to layout an green and power-awareness protocols on the way to enlarge the lifetime of the in-tact networks in WSN'. Sensor nodes existence time is one of the most vital parameters in Wireless Sensor Network, together with the difficulty of figuring out appropriate cluster-heads and strength green routing protocol in wi-fi sensor networks. This has currently been the focal point of studies and development, where many researches are operating on those lifetime extension. This studies work and take a look at for that reason explained on this thesis, is stimulated through allowing rotation of cluster head function a few of the sensor nodes seeking to distribute the power intake optimally over all nodes within the network. Selection of cluster head for such rotation greatly complements the strength efficiency of the community. As a part of this thesis and studies work, many special routing protocols and algorithms are investigated to discover ways to lessen power consumption. In this thesis protocols are proposed for both homogeneous and heterogeneous WSNs, which shows different cluster head selection strategies and diverse cluster formation techniques. Comparison of their costs (in phrases of strength) of cluster head selection in exceptional rounds and different extensive results like cluster formation strategies, selection and distribution of cluster heads in addition to introduction of

clusters shows a want of a mixed strategy for mentioning optimum and better effects.

2. Related Work:

Minimizing electricity consumption to maximize community lifetime is one of the crucial worries in designing wi-fi sensor community routing protocols. Cluster-based totally protocols have shown promising strength-efficiency overall performance, in which sensor nodes take turns to act as cluster heads (CHs), which carry out higher-stage facts routing and relaying. In such case the electricity intake is extra evenly disbursed for all of the nodes. However, most cluster-based totally protocols improve power-performance at the fee of transmission delay. In this paper, **D. Yi, (2016) [6]** advise an progressed put off-conscious and power-efficient clustered protocol known as Hamilton Energy-Efficient Routing Protocol (HEER). HEER paperwork clusters within the community initialization segment and links members in each cluster on a Hamilton Path, constructed using a greedy algorithm, for statistics transmission reason. No cluster reformation is needed and the members on the direction will take turns to grow to be cluster head. The design lets in HEER to shop on community administration energy and also balance the load comparing to standard cluster-based protocols. The algorithms designed in HEER additionally way that it does now not suffer long postpone and does now not require every node to have international place statistics evaluating with conventional chain-based protocols together with PEGASIS and its versions. We implemented the HEER protocol in MATLAB simulation and as compared it with several cluster-based totally and chain-based protocols. We found that HEER is able to acquire an advanced network lifetime over the present day protocols whilst maintaining the average statistics transmission put off.

A cluster-primarily based version is most suitable in wireless sensor community due to its capacity to lessen electricity intake. However, coping with the nodes within the cluster in a dynamic surroundings is an open undertaking. Selecting the cluster heads (CHs) is a cumbersome method that significantly impacts the network overall performance. Although there are several research that advocate CH choice methods, most of them aren't suitable for a dynamic clustering surroundings. To keep away from this hassle, numerous strategies had been proposed primarily based on shrewd algorithms such as fuzzy logic, genetic algorithm (GA), and neural networks. However, those algorithms work higher inside a unmarried-hop clustering version framework, and the network lifetime constitutes a huge issue in case of multi-hop clustering environments. **Mohamed Elhoseny, (2017) [7]** introduced a brand new CH choice technique based totally on GA for each unmarried-hop and the multi-hop cluster fashions. The proposed method is designed to meet the requirements of dynamic environments by using electing the CH based totally on six principal functions, namely, (1) the final electricity, (2) the ate up electricity, (3) the range of close by buddies, (four) the energy aware distance, (5) the node vulnerability, and (6) the diploma of mobility.

Extending the life of wireless sensor networks (WSNs) while delivering the anticipated degree of provider remains a warm studies subject matter. Clustering has been recognized within the literature as one of the number one method to shop conversation power. In this paper, **Tariq Taleb, (2017) [8]** argue that hierarchical agglomerative clustering (HAC) gives a suitable foundation for designing notably electricity efficient conversation protocols for WSNs. To this give up, we look at a brand new mechanism for deciding on cluster heads (CHs) primarily based both on the bodily area of the sensors and their residual power. Furthermore, we examine specific styles of communications between the CHs and the bottom station depending on the viable transmission tiers and the capacity of the sensors to act as visitors relays. Simulation results display that our proposed clustering and communication schemes outperform nicely-is aware of existing techniques by means of comfy margins. In specific, networks lifetime is extended by means of greater than 60% as compared to LEACH and HEED, and by extra than 30% as compared to K-approach clustering. In this paper, the several clustering and communique schemes to improve power-performance of WSNs and subsequently boom their lifetime were proposed.

Clustering is a promising and famous technique to prepare sensor nodes right into a hierarchical shape, lessen transmitting statistics to the base station through aggregation methods, and lengthen the network lifetime. However, a heavy site visitors load might also reason the unexpected dying of nodes because of energy resource depletion in some network areas, i.e., warm spots that result in community carrier disruption. This problem could be very vital, specifically for information-collecting situations wherein Cluster Heads (CHs) are accountable for gathering and forwarding sensed statistics to the base station.To keep away from warm spot hassle, the network workload should be uniformly disbursed among nodes. This is performed by means of rotating the CH position among all network nodes and tuning cluster length in keeping with CH situations. In this paper, a clustering algorithm is proposed by **Peyman Neamatollahi, (2018) [9]** that selects nodes with the highest ultimate electricity in each area as candidate CHs, among which the excellent nodes will be picked because the very last CHs. In addition, to mitigate the new spot problem, this clustering set of rules employs fuzzy common sense to alter the cluster radius of CH nodes; this is based totally on some nearby facts, consisting of distance to the bottom station and local density. Simulation effects display that, by means of mitigating the new spot problem, the proposed approach achieves an improvement in phrases of each network lifetime and strength conservation. Because power constraint is a big challenge when designing WSNs, many research have been executed to acquire strength-green algorithms.

Proficient clustering method has a essential function in organizing sensor nodes in wi-fi sensor networks (WSNs), utilising their energy sources efficaciously and imparting durability to community. Hybrid strength-efficient distributed (HEED) protocol is one of the prominent clustering protocol in WSNs. However, it has few shortcomings, i.e., cluster heads (CHs) version in consecutive rounds, extra paintings load on CHs, choppy energy dissipation through sensor nodes, and formation of warm spots in community. By resolving those troubles, you could decorate HEED abilties to a greater volume. We have designed versions of Optimized HEED (OHEED) protocols named as HEED-1 Tier chaining (HEED1TC), HEED-2 Tier chaining (HEED2TC), ICHB-based OHEED-1 Tier chaining (ICOH1TC), ICHBbased

OHEED-2 Tier chaining (ICOH2TC), ICHB-FLbased OHEED-1 Tier chaining (ICFLOH1TC), and ICHBFL-primarily based OHEED-2 Tier chaining (ICFLOH2TC) protocols. In HEED1TC and HEED2TC protocols, **Prateek Gupta, (2017) [10]** have got used chain-based intra-cluster and inter-cluster communication in HEED, respectively, for even load balancing among sensor nodes and to avoid more paintings load on CHs.

3. Methodology:

HAC is a typical clustering method based on partition, and its whole procedure can be divided as follows: at first, every node acts as a one-node cluster; then these small clusters begin to merge each other to the larger ones; and repeat to merge small clusters until all clusters' scale has satisfied the threshold. In this paper, an improved HAC clustering method which the nodes' residual energy is added into calculation distance is designed.

3.1The introduction of classical HAC

The procedure of HAC includes five operations: calculation the distance of every pair of nodes, initial clustering, electing CH of all clusters, merging small clusters, and electing new CH. In this section these five operations would be explained by three steps:

Step 1: Distance calculation. Distance means the difference of a pair of nodes and it is the basis of clustering. In WSNs, the spatial distance is the most important factor of energy consumption, and Euclidean formula is the most used method to calculate the spatial distance of any pair of nodes as the following equation:

$$D_{ob} = \sqrt{(X_0 - X_b)^2 + (Y_0 - Y_b)^2} \quad (1)$$

In Eq. (1), Xa and Ya respectively represent X axis Y axis of node a, and Xb and Yb respectively represent X axis Y axis of node b. The axis of nodes in Fig. 1 is shown in Table 1, and the result of every pair of nodes by Eq. (2)

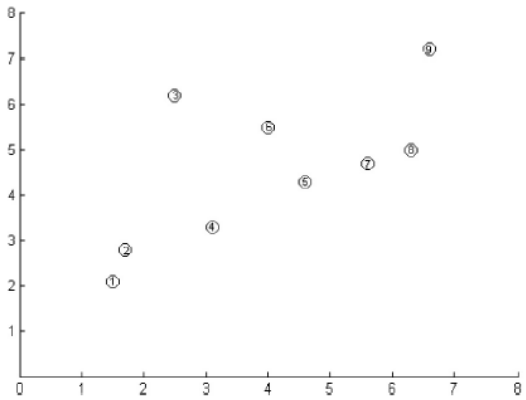

Fig. 1. A typical model of WSNs' deployment station.

Step 2: Primary clustering. In this step, each node acts as CH, and sends its own information such as its location, clusters structure to its neighbor nodes. Then every CH would calculate distance from itself to other clusters, and would build a matrix to reserve the result. there are three mainly calculation formulas in application including maximum nodes distance as Eq. (3), minimum nodes distance as Eq. (4) and average nodes distance as Eq. (5). In these formulas, D(i, j) is the distance from node i in cluster A to node j in cluster B, and there are m nodes in cluster A and n nodes in cluster B. In these methods, Eq. (5) is the most popular ones, and it is also applied in EESSC to build distance matrix.

$$D_{Slin1_{(}} = Mi \uparrow \iota(D(1,1), D(1,2), \dots, D(i,j), \dots, D(m, \uparrow \iota)) \quad (2)$$

$$D_{C1inlc} = Mox(D(1,1), D(1,2), \dots, D(i,j), \dots, D(m, \uparrow \iota)) \quad (3)$$

$$D_{PGMA} = \frac{\iota}{mn} \sum_{3i=12_{r,\dots:m,j=12i3,in}} \dots D(i,j) \quad (4)$$

Step 3: Merge clusters. In this step, the smaller clusters would be merged into big ones judging by the calculation result of the formula introduced in step 2, and the new CH would be elected meanwhile. Because it has not a unified standard to elect CH in HAC, and according to the speciality of energy efficiency, a concept named SEPC (the Summary of Every Pair of nodes in Cluster, SEPC) would be adopted. The SEPC would be calculated by Eq. (5), and the node with minimum SEPC would be elected as CH, and in Eq. (5) n means the number of nodes in cluster. After merging clusters, it would be judged if the scale of all clusters has satisfied the threshold. If there still is small cluster, all CHs would broadcast their clusters' information, and the merging operation would be repeated. The distance of each cluster after one time merging is listed in Table 3, and the procedure of WSNs shown in Fig. 1.

$$C(i) = \sum_{j=lj\neq i}^{n} D\,(i,j) \quad (5)$$

1 PACT.ID=SN; PACT.axe=SN.axe; PACT.ene=infinity;
//Set the initial information of PACT
2 SN sends the PACT to the one-hop neighbor nodes;
3 The nodes receive the PACT;
4 Clisti.head=IDi;
//set itself as CH, and create LNC;
5 If PACT.ID not in DLOCi
//if the node i has not the distance information to last node
6 If PACT.ID!=SN
//and the packet is not directly sent from SN
7 ID joins the DLOCi and the value of the item is computed as Eq. (6) and procedure as Fig. 8;
8 Send the PCON to the source;
9 End if
10 Updating PACT;
// the information of node i would be written in PACT;
11 Forward the PACT to the one-hop neighbor nodes;
12 Else if PACT.ene < the one in DLOCi
13 Updating DLOCi;
//ensure the information in DLOCi is acute;
14 Receive the PCON;
// receive the PCON to ensure that the DLOCi is completely
15 If Pcon.ID not in DLOCi
16 ID join the DLOCi and the value of the item is computed as Eq. (5);
17 End if
18 Go to procedure merge clusters;
19 End procedure

3. Result and Discussion:

In existing researches, there are two standards to calculate the WSNs' lifetime: the first, if there is just one node dead, the WSNs should be seemed failure; the other, if there are over a ratio (mostly, 30%) sensor nodes dead, the WSNs should be seemed failure. The both two standards are applied in the proposed algorithm. And to overall and exactly estimate different algorithms, there are three kinds of simulation for all algorithms: the lifetime's variability with the number of sensor nodes increase; the lifetime's variability with the change of

sink node's location; and the lifetime's variability with the increase of sensor nodes initial energy. The results of simulations are respectively shown in Figures. On the condition that sensor nodes have the stable initial energy (0.5 J), and the sink node is just located in the different spot of area, the simulation results are shown. The conclusion is draw from Figures that the lifetime of proposed fuzzy embedded clustering algorithm is better than the best one results of base paper. And from the curves of all algorithms, fuzzy embedded clustering has increasing advantage with nodes increasing, which proves that it would be fittest for the environment of all on the condition of 100% nodes alive.

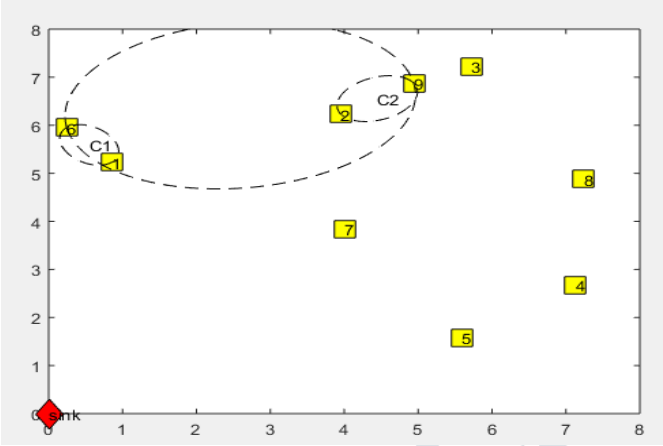

Fig. 2: Developed WSN with clustering at first round and sink at origin.

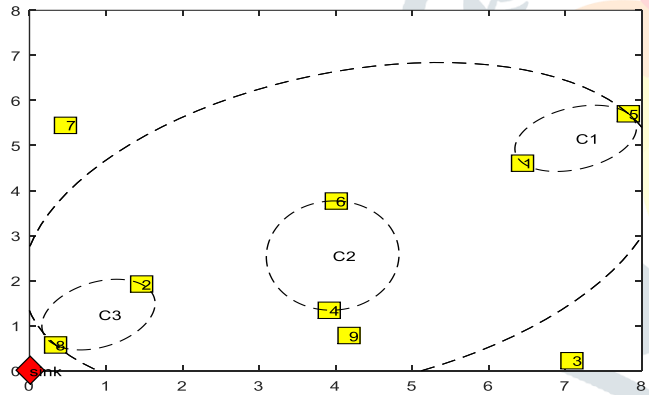

Fig 3: Developed WSN with clustering at second round and sink at origin.

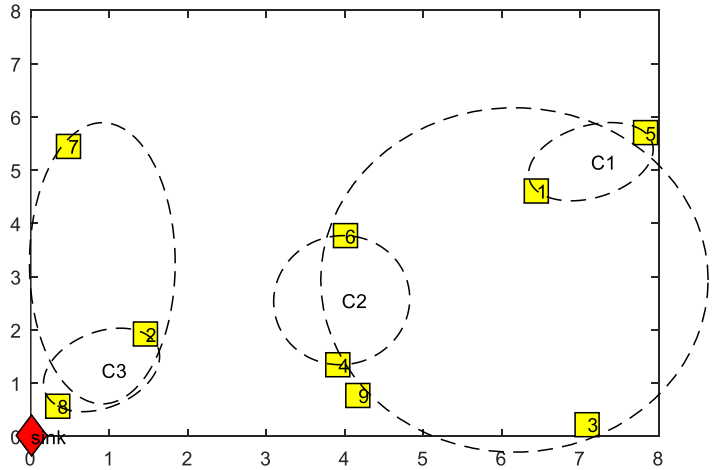

Fig 4: Developed WSN with clustering at third round and sink at origin.

5. Conclusion:

To improve the performance of WSN, raising the sensor nodes's energy efficiency is one of the most important methods. ''Hot Spot'' and ''Energy Hole'' are two main problems to be resolved to improve energy efficiency, and many hierarchical routing algorithms have been designed to attain this goal. In this paper, after analyzing the mainly existing algorithms, a new energy aware hierarchical routing algorithm based on fuzzy logic is proposed. There are four innovations about this algorithm as: firstly, a new energy aware clustering method based on node energy and position based clustering is designed to make the cluster of sensor nodes more reasonable; secondly, a special kind of list storing cluster member nodes is defined to rotate CH automatically; thirdly, a special packet head is designed to dynamically update the nodes's residual energy information when transmitting message; at last, one kind of re-clustering mechanism is designed to optimize the clusters' distribution. A typical hierarchical routing algorithms are simulated with fuzzy embedded clustering by Matlab. Through the comparison, it can be concluded that proposed algorithm has advance in energy efficiency of all algorithms, and resolves the problems of ''Hot Spot'' and ''Energy Hole''.

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