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REVIEW ARTICLE

A Comprehensive Review of Distance and Density Based Cluster Head Selection Schemes

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Abstract - One of the most important consideration in designing sensor nodes in a wireless sensor network for prolonging the network lifetime by minimizing energy consumption. The number of cluster and the distribution of cluster heads (CHs) always make a major impact on the network performance. Distance and Density based clustering algorithm can greatly improve energy efficiency of WSNs because it adopts a multi-hop communication in each cluster. Besides, the neighborhood of the sink node (SN) will perform direct transmission to relieve the workload of CHs. Load balancing and scalability are very crucial factors which plays important role in the selection of Cluster head. In this paper we present the study of different distance and density based cluster head selection algorithms for wireless sensor networks and compared them on various parameters.

Keywords: Sink Node (SN); Distance; Cluster Head (CH); Density; Hops, Wireless Sensor Networks, Cluster Head Selection Schemes

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I. INTRODUCTION

Wireless sensor networks are envisioned to be economic solutions to many important applications such as real time traffic monitoring, military surveillance and home security. WSN is the autonomous network consisting of a large number of sensor nodes and a base station. The sensor nodes act as information source to measures some of the physical phenomena and reports them to base station (BS). Then, the base station aggregates the received sample data. However, since sensor nodes are constrained by scarce resources in memory, computation, communication and battery, it is very inefficient for every sensor nodes to report their raw data back to base station which have to traverse many hops to reach BS [6][10][13].

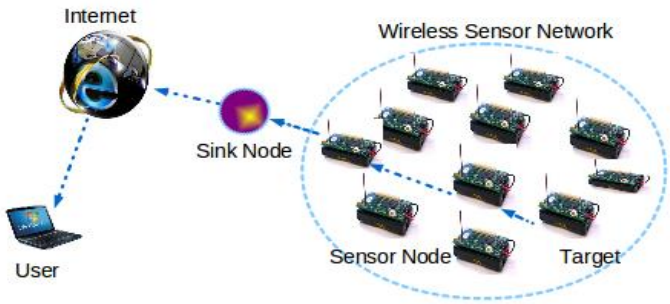

Fig. 1 Wireless Sensor Networks

To study efficient routing algorithms is an important and challenging research issue. The essence of routing algorithms is to find an optimal path that enables the efficient exchange of information between source node and base station, and to ensure correct transmission of data along the path. As the battery, capability of computing, storage and data processing of a sensor are limited, how to reduce the energy consumption while prolonging the network lifetime stays the key problem.

Most routing algorithms are based on two categories of network structure: planner and hierarchical. For planner routing algorithms, as all nodes have equal roles, traffic is evenly distributed across the network. However, the network lacks scalability, and both data transmission and the route discovery and maintenance procedure cost much resource. For hierarchical routing algorithms, clustering methodology is adopted which divides network into clusters and makes cluster heads responsible for data aggregation [4]. Clustering is very much useful in those cases where sensor nodes are densely deployed causing them to detect common phenomena leading to high redundancy in their sensed raw data. Thus reporting raw data is often unnecessary. The data aggregation protocols designed for WSNs exploits the naturally existing data redundancy and computes the aggregate data, thereby reducing the communication cost and energy expenditure in data collection. During a typical data aggregation process, sensor nodes are organized into groups forming a hierarchical structure with the root at BS. Within the hierarchical structure, the non-leaf nodes act as aggregators or cluster heads and others as members. The leaf nodes send their raw data to their immediate aggregator which fuses the data collected from its children and forwards the fusion result to BS. In this way, data are processed and fused at each hop on the way to the BS, and communication overhead is greatly reduced.

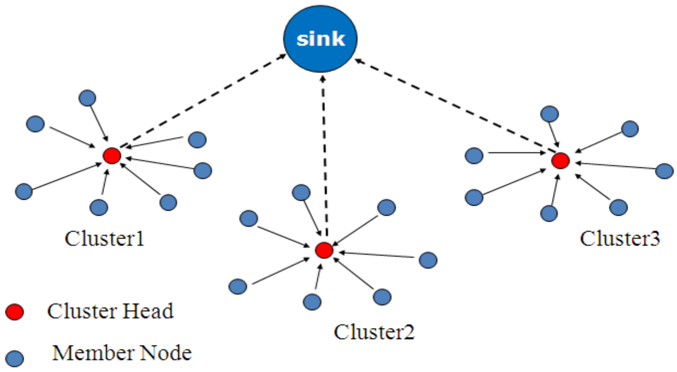

Fig. 2 Clustering in WSN

A. Clustering has following advantages:

1) Instead of sending data directly to the base station makes it a long-distance data transmission, In clustering the sensors only need to send data to cluster heads. Then cluster-heads aggregates the received data and eliminate redundancy of received data and send the aggregated information to the base station. Thus the amount of data communication is reduced.

2) Clustering topology is especially suitable for large-scale deployed network.

3) Since most of the nodes close their communication module for relative long time, it can reduce energy consumption and significantly prolong the lifetime of the entire network [4].

The remainder of the paper is organized in follows: Section 2 presents overview of literature review of clustering algorithms WSNs. Section 3 presents some cluster head selection algorithms based on distance and density in the networks. 4 present the comparison of diff. distance and density based cluster head selection algorithms. Section 5 presents conclusion of the paper and future research.

II. LITERATURE REVIEW

Many energy-efficient routing algorithms have been proposed based on the hierarchical topology. One of the most well-known clustering approaches is LEACH (Low- Energy Adaptive Clustering Hierarchy) [3] a clustering-based protocol that utilizes a randomized rotation of local cluster head to evenly distribute the energy load among the sensors in the network. But, since node has different communication distance and remainder energy, LEACH cannot have chance to cluster head and consume their energy evenly with only probability. In addition, when the cluster head select, the cluster head causes on additional overhead to estimate the sum of the current energy. Directed diffusion (DD) [1] is a query-based routing protocol for wireless sensor networks. By using data aggregation, caching and reinforcement techniques, the appropriate link is dynamically selected from the candidates. Rumor routing protocol [2] uses forwarding query messages randomly to reduce the overhead of route establishment. Density-based Clustering Protocol (DBCP) [5] is an improvement for LEACH on the basis of nodes' connectivity. A metric of nodes' relative density is introduced for cluster-head selection, as it is shown in Eq. (1).

$$T(n) = \begin{cases} \frac{P}{1-P[r \bmod (1/P)]}\left(1+\frac{Neighbor(n)\_alive-1/P}{Network\_alive}\right) & if \quad n\in G, \\ 0 & otherwise \end{cases} \quad (1)$$

where 1/P represents the average number of nodes in one cluster. By comparing to the alive neighboring nodes of n in certain round, the formula promotes that nodes in dense area have larger probability to become cluster head. Unlike LEACH, where nodes self-configure themselves into clusters, LEACH-C (LEACH-Centralized) [7] utilizes the base station for the cluster formation. During the setup phase of LEACH-C, the base station receives information regarding the location and energy level of each node in the network. Using this information, the base station finds a predetermined number of cluster heads and configures the network into clusters. The cluster groupings are chosen to minimize the energy required for non-cluster head nodes to transmit their data to their respective cluster heads. But, at the beginning of each round, LEACH-C causes on additional overhead to receive information from each node about their location and energy level for the centralized cluster formation algorithm. In TEAM [8] message complexity is reduced. Intermediate nodes bid to redirect the path by advertising the aggregate transmission power, the route may not be energy-efficient though. VGTR [9] judges the energy consumption of the paths and takes notice of nodes with low remaining energy or high information value. Unequal clustering algorithms like [11] aim to solute the energy hole problem. For the clusters, the closer they are to the sink, the smaller size they are formed. It saves energy for inter-cluster communications. However, too many clusters around the sink will produce a large number of summary packets that leads to heavy traffic load.

III. CLUSTER HEAD SELECTION SCHEMES

A. Distance and density based cluster head selection (DDCHS) [12]

Distance and density based cluster head selection algorithm divides the cluster region into perpendicular diameter and selects the cluster heads based on distance and density of the member nodes in wireless sensor networks.

1) DDCHS Algorithm

STEP 1: Divide the cluster area into two perpendicular diameter that makes four quadrants where M is the size of sensor field, R is the communication radius of initial cluster head, C(x,y) is a position of initial cluster header, C'(x',y') is a center of inscribed circle as shown in fig.3.

STEP 2: Compare the node density i.e the number of cluster members in each quadrants and select candidate quadrants.

STEP 3: Compare the node distance i.e from nearest cluster heads in candidate quadrants.

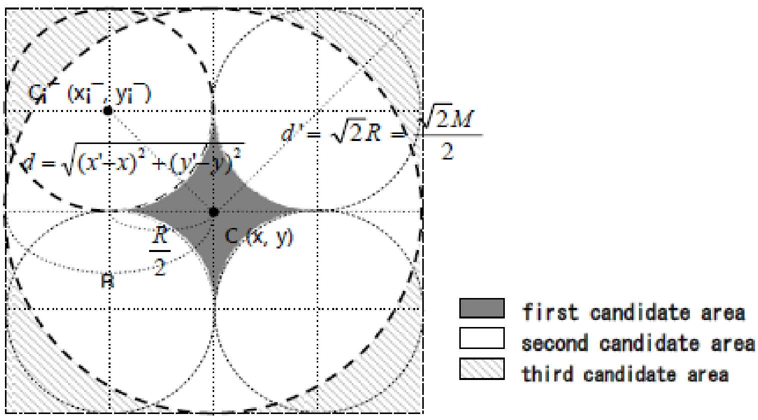

Fig. 3 Grouping of divide cluster area

Once the nodes are chosen as cluster heads, then the cluster heads advertise its status message to all its neighbor nodes and invite all the neighbor nodes to join in the cluster. The member nodes join the nearest cluster head and register itself as a cluster member.

Cluster Head Selection Algorithm

STEP 1 : INITIALIZE

1: $Set_{mem} \leftarrow$ {u : lies within my cluster range}

2: If (is_exist_CH == True)

3: my_cluster_head = nodeID

4: $Set_{grp} \leftarrow$ set grouping by divide cluster area

5: else

6: compute and broadcast cost to $\in set_{mem}$

7: $Set_{CH} \leftarrow$ max (energy)

8: my_cluster_head = nodeID

9: $Set_{grp} \leftarrow$ set grouping by divide cluster area

10: end if

STEP 2 : REPEAT

11: If (is_exist_CH == False)

12: Go to STEP 1

13: else

14: **If** (Set_{grp} == False)

16: Go to STEP 1

17: **else**

19: compute and broadcast cost to $\in set_{grp}$

20: $CH_{grp} \leftarrow$ max (density)

21: compute and broadcast cost to $\in CH_{grp}$

22: $Set_{CH} \leftarrow$ min (distance)

23: my_cluster_head = nodeID

24: cluster_head_msg (nodeID, position)

end if

end if

B. Density-based Energy-efficient Clustering Algorithm (DECA) [4]

Due to the evaluation of density, DECA evenly distributes the cluster heads. The residual energy of each cluster head is being considered after each round of cluster head selection. By this way energy conservation can be reduced which can prolong the lifetime of WSNs.

1) DECA Cluster head Selection

If we assume N sensor nodes in a M * M square region are divided into k clusters and R representing the standard transmission radius for message exchange during the set-up stage of clusters. Than we have:

$$M \times M = k\pi R^2 \Rightarrow R = \frac{M}{\sqrt{Xk}} \qquad (2)$$

Than we selects cluster head based on density (den) of each node. Here, the metric of density represents the number of nodes located within a circle region for searching that takes the node itself as the center and R as the radius. The density of Si can be calculated via searching the entire network as Eq. (2), where d(Si, Sx) represents the distance between Si and another node Sx.

$$den(s_i) = \sum_{0<x\leq N \ \& \ d(s_i, s_x)\leq R} 1 \tag{3}$$

The cluster head selection procedure performs in "k" rounds. In each round the density value is sorted in descending order. Then the node with largest density (den) is chosen as cluster head. If two or more nodes have the same density (den), then one can be randomly chosen as cluster head. The cluster heads always consumes more energy than other member nodes. In DECA, after several rounds the cluster heads may have drain out their energy and that will affect the network lifetime. So, to solve this problem metric "n" as energy level of each cluster head whether each existing cluster head's role should be changed. In following Eq.4, n is proportion of the "E residual" energy of cluster head in its initial energy "E initial".

$$\eta = \frac{Eresidual}{Einitial} \tag{4}$$

In DECA predetermine the "n threshold" number such as 10%. If "n" is less than "n threshold", than cluster becomes normal node and will not do any aggregation.

C. Density-based Energy-efficient Game-theoretic Routing Algorithm (DEGRA) [14]

DEGRA is a hierarchical routing algorithm, in which clustering is being done and ensures even distribution of cluster heads due to the evaluation of node's density. The residual energy and average energy consumption of Cluster head's neighboring nodes are under consideration. By selecting relatively powerful cluster heads, DEGRA alleviates the energy problem and prolong the network lifetime.

1) DEGRA Cluster Head Selection Algorithm

In the game-theoretic model, cluster heads are acts as players and transmit data to the base station (BS) which is often far from the sensing field. The cluster head selection is based on game-theoretic model which can be described as:

STEP 1: All nodes calculate their utility value "u" and then broadcast a message to all other nodes in the network.

STEP 2: If a received node has smaller utility value then it will broadcast the original received message. But if received node has larger utility value than received message, then it will become cluster head and broadcast a new message with its own information. The nodes with same utility value will compare their ID and the node with smaller ID will win.

STEP 3: After comparing all the nodes in the network, the node with highest utility value will become the cluster head. For selecting "k" cluster heads, "k" no. of rounds will be performed iteratively. Then the cluster heads send the NEIGHBOR_MSG which contain communication radius "R comm_radius", its ID and information of its residual energy. Any node in its (CH) communication radius becomes its neighbor. Flags specify that all nodes have been studied. After choosing "k" cluster heads in "k" rounds, then clustering process ends.

Cluster Head Selection Algorithm

1: $\mu \leftarrow 0$

2: $Flag_\alpha \leftarrow 0$, $\alpha = 1, 2, ..., n$

3: **while** $\mu < k$ **do**

if u_i = mac{u_α}, $Flag_\alpha = 0$ **then**

beClusterHead ← TRUE

$Flag_i = 1$

broadcast a NEIGHBOR_MSG (S_i.ID)

end if

on receiving a NEIGHBOR_MSG (S_i.ID) for node S_j

if $d(S_i, S_j) \leq R_{comm\_radius}$ **then**

$Flag_j = 1$

broadcast a QUIT_SELECTION_MSG (S_j.ID) and **then EXIT**

$\boldsymbol{\mu \leftarrow \mu + 1}$

end while

IV. COMPARISON OF DIFFERENT CLUSTER HEAD SELECTION ALGORITHMS

The selection of optimal number of clusters and the distribution of cluster heads (CHs) have a major impact on the network performance. So, In this paper there are three most recently used cluster head selection algorithms are compared:

Table 1 Comparison of Distance and Density Based Cluster Head Selection Algorithms in WSN

Cluster Head Selection Algorithm	**Energy Efficiency**	**Network Lifetime**	**Main Consideration**	**CH Selection is based on**
DDCHS	Good	Good	1. Distance of Sink from Target Region. 2. Density of Nodes in the Network.	Distance and density
DECA	Good	Good	1. Residual Energy of nodes after each round.	Density and residual energy of nodes
DEGRA	Very Good	Best	1. Residual Energy & Avg. Energy 2. Consumption of its neighboring nodes.	Game theory, Residual Energy and Avg. Energy

V. CONCLUSION

In wireless sensor networks, clustering algorithms are widely used and these are the most popular routing methodologies that can effectively manage network energy consumption through data aggregation. The selection of cluster heads is one of the most important concerns in WSNs. Each sensor node may prefer to transmit data directly to the sink node without having any extra communication with neighbor nodes. However, it results in more energy consumption for transferring data in the network. In this paper we have surveyed the past research works which mainly focuses on energy efficient clustering head selection algorithms for wireless sensor networks and we have systematically analyzed a few distance and density based cluster head selection algorithms in deep, and compared these different schemes based some primary metrics.

REFERENCES

[1] C.Intanagonwiwat, R.Govindan, and D.Estrin, “Directed diffusion: A scalable and robust communication paradigm for sensor networks”, *Proc. 6th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom'00)*, pp.56-67, Aug. 2000.

[2] D.Braginsky, and D.Estrin, “Rumor Routing Algorithm For Sensor Networks”, *WSNA’02*, September 28,2002.

[3] W. R. Heinzelman, A. Chandrakasan, H. Balakrishnan, "energy-efficient Communication Protocol for wiireless Microsensor Networks,” in *Proceedings of HICSS*, 2000.

[4] Zhanyang Xu, Yue Yin and Jin Wang, “A Density-based Energy-efficient Clustering Algorithm for Wireless Sensor Networks,” *in International Journal of Future Generation Communication and Networking* Vol. 6, No. 1, February, 2013.

[5] J. F. Qiao and S. Y. Liu, X. Y. Cao, “Density-based Clustering Protocol for Wireless Sensor Networks”, *Computer Science*, vol. 12, **(2009)**, pp. 46.

[6] N. Chitradevi, V. Palanisamy, K. Baskaran and K. Swathithya, “Efficient Density Based Techniques for Anomalous Data Detection in Wireless Sensor Networks,” in *Journal of Applied Science and Engineering*, Vol. 16, No. 2, pp. 211223 (2013).

[7] W.Heinzelman, “An Application-Specific Protocol Architectures for Wireless Networks”, *Ph.D. Thesis*, Massachusetts Institute of Technology, pp.84-86, 2002.

[8] F. J. Cai and U. Pooch, “Play Alone or Together-truthful and Efficient Routing in Wireless Ad Hoc Networks with Selfish Nodes”, *Proceedings of IEEE International Conference on Mobile Ad-hoc and Sensor Systems*, **(2004)** October 25-27; Fort Lauderdale, Florida, USA.

[9] A. Schillings and K. Yang, “VGTR: A Collaborative, Energy and Information Aware Routing Algorithm for Wireless Sensor Networks Through the Use of Game Theory”, *Lecture Notes in Computer Science*, vol. 5659, **(2009)**, pp. 51.

[10] Naveen Sharma and Anand Nayyar, “A Comprehensive Review of Cluster Based Energy Efficient Routing Protocols for Wireless Sensor Networks,” in *International Journal of Application or Innovation in Engineering & Management (IJAIEM),* Volume 3, pp. 441-453, January 2014.

[11] B. S. Lee, H. W. Lin and W. Tarng, “A Cluster Allocation and Routing Algorithm Based on Node Density for Extending the Lifetime of Wireless Sensor Networks”, *Proceedings of the 26th International Conference on Advanced Information Networking and Applications Workshops (WAINA)*, **(2012)** March 26-29; Fukuoka, Japan.

[12] Kyounghwa Lee, Joohyun Lee, Hyubgun Lee and Youngtae Shin, “A Density and Distance based Cluster Head Selection Algorithm in Sensor Networks,” in 2012.

[13] Agam Gupta and Anand Nayyar, “A Comprehensive Review of Cluster Based Energy Efficient Routing Protocols in Wireless Sensor Networks”, in *International Journal of Research in Computer and Communication Technology*, Vol. 3, January, 2014.

[14] Zhanyang Xu, Yue Yin and Jin Wang, “An Density-based Energy-efficient Routing Algorithm in Wireless Sensor Networks Using Game Theory,” in *International Journal of Future Generation Communication and Networking* Vol. 5, No. 4, December, 2012.

[15] Shuchi Sharma and Anand Nayyar, “A Survey on Coverage and Connectivity Issues Surrounding Wireless Sensor Network,” in *International Journal of Research in Computer and Communication Technology*, Vol. 3, January, 2014.