

Performance Evaluation of FSC Routing Protocol in Wireless Sensor Networks

Raghavendra Y M

Asst Professor, Dept Of Ece,
Gsssiw, Mysuru
Karnataka, India

Shyamala.C

Asst Professor, Dept Of Ece
Gsssiw, Mysuru
Karnataka,India

Asha. M

Asst Professor, Dept Of Ece
Gsssiw, Mysuru
Karnataka,India

Abstract— Minimization of energy consumption in nodes as well as uniform energy depletion of the nodes, are critical parameters in order to increase the lifetime of a network. The major cause for energy depletion is due to the need for transmitting the sensed data from the sensor nodes (SNs) to remote sinks. These data are typically relayed using ad hoc multi-hop routes in the WSN. A side-effect of this approach is that the SNs located closer to the sink are heavily used to relay data from all network nodes; hence, their energy is consumed faster, leading to a non-uniform depletion of energy in the WSN.

Because of more data collections and more packet transmission, the usage of energy of the system is more. For performing best clustering process Fan – Shaped Clustering (FSC) is used, where the large scale network is partitioned into fan-shaped clusters. In this approach performed with various combination of energy saving methods such as selection of cluster head and relay node, implementation of re-clustering and an efficient routing method and hotspot solution. For reducing signaling cost, localization re-clustering process performed. Selection of CH, Initially central area has been introduced. The usage of CH selection can optimize the intra-communication cost and reduce re-clustering frequency. Every CH pass the packet to their relay node, then the relay node transferred the packets to the next inner cluster group. All this process enabled the network to achieve good performance. Finally analyze the performance based on the different criteria such as the total alive nodes, the total residual energy and the packet collection rate with the some important parameters radius of central area, the energy threshold for relays and CHs.

Keywords: WSN, FSC, CH.

I.INTRODUCTION

Recent developments in wireless communications have provided low cost and small size sensor nodes [1]. A wireless sensor network consists of thousands of limited resource sensor nodes, used to collect information from the surrounding environment. These sensor nodes are able to communicate with each other and also with base station (BS) [2]. In other words, each sensor node can sense, process and transfer data to the BS. Due to some constraints on the size and the cost of sensor nodes, they usually are equipped with limited and non-

rechargeable batteries; therefore, reducing the amount of energy dissipation is an important challenge in the network lifetime.

To reduce energy consumption, unnecessary information should not be sent to the BS. It has been proved that clustering is an effective scheme in reducing energy consumption and increasing the scalability of the WSNs. In this method the network is divided into some separate clusters. Each cluster has a cluster head (CH) and each sensor node belongs to a cluster to deliver the sensed data to its cluster head. Finally, each CH aggregates the received data and sends it to the BS. Since some sensor nodes are located around a special event similar data would be sent to the CH, aggregation mechanisms in the CH can reduce the amount of transmitted data to the BS. Hence, the energy consumption reduces significantly in the sensor nodes. Furthermore, [3] network coverage is another challenge especially in large scale WSNs such as military applications [4]. In such networks, it is important to cover the whole network area while decreasing the overlap between clusters [5].

In other words, decreasing the overlapping areas has a significant influence on the reduction of the energy dissipation. In the clustering algorithms, there are two kinds of communications, intra-cluster and inter-cluster communications. In intra-cluster, since the distance between CH and sensors are too short, the commutation is established by one or at most two hops.

However, in inter-cluster communication the distance between CHs and BS may grow extremely. In previous researches [6], it has been shown that multi-hop communication between a data source and a data sink is usually more energy efficient than direct transmission. The main problem of this approach is that the sensors closer to the BS suffer from heavy relay traffic. Therefore, they die much sooner than other sensors, thus sense coverage of the network decreases.

II.BLOCK DIAGRAM

As shown in figure.1 the network is created by first placing the sink and then deployment of nodes. The clusters are formed using fan shaped clustering. Based on position of node cluster Head is chosen. Depending on the layer in which Source node is selected routing path is finalized and packets are transmitted. The flow diagram is shown in figure.2 .

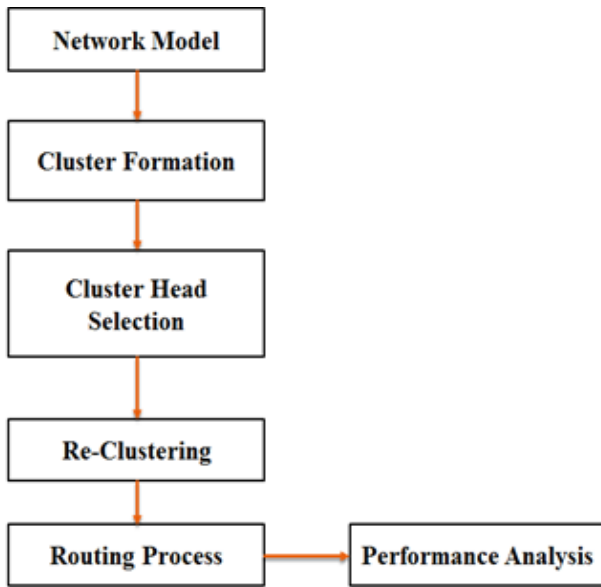


Fig 1 Block diagram

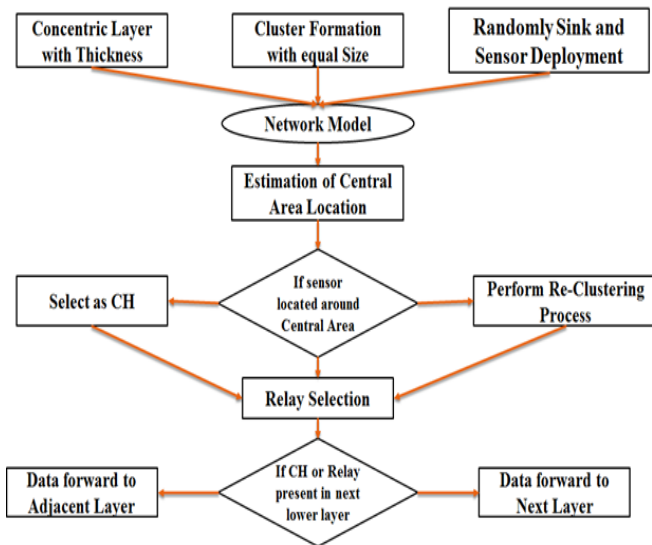


Fig 2 Flow Diagram

III. MODULES

- Network Model
- Cluster Formation
- Cluster Head Selection
- Routing Process
- Performance Analysis

Modules Description:

A. Network Model

Initially disk is drawn, which is divided into M disjoint concentric coronas with thickness $\omega = R / M$. where, R denotes the disk Radius and M represents the number of concentric coronas. Next arbitrary wedge is subtended by an angle of θ and this wedge is sub divided into M sectors. That

intersect point with concentric coronas is denoted as $\Omega_1, \Omega_2, \Omega_3, \dots, \Omega_M$.

In this network model one stationary sink is centered at the network model which has sufficient power supply. Multiple stationary ordinary nodes are located in the network model which is powered by batteries with limited energy. Node in this model has uniform initial energy and maximal transmission range.

B. Cluster Formation

Here proposed Fan-Shaped Clustering algorithm where network is to partition this large-scale network (sensor field) into fan-shaped clusters. Then based on this clustering, we design mechanisms including cluster head (CH) selection, cluster re-partition, and routing, to achieve network lifetime maximization.

Cluster formation algorithm, we use the same simulated annealing to minimize the energy consumption for cluster nodes when transmitting data to the cluster head. Randomly choose a node among the eligible nodes to become cluster head but we also make sure that the nodes are separated with a minimum separation distance (if possible) from the other cluster head nodes.

C. Cluster Head Selection

In the cluster head selection part, cluster heads are randomly chosen from a list of eligible nodes. To decide which nodes that is eligible, the average energy of the remaining nodes in the network is calculated. In order to spread the load evenly, only nodes with energy above the average energy are eligible.

The leader nodes of the clusters (CHs) in some proposed algorithms (mainly for heterogeneous environments) can be pre assigned. In most cases however (i.e., in homogeneous environments), the CHs are picked from the deployed set of nodes either in a probabilistic or completely random way or based on other more specific criteria (residual energy, connectivity etc.). Thus, the time complexity or convergence rate of most cluster formation procedures proposed nowadays is constant (or just dependent on the number of CHs or the number of hops). In some earlier protocols, however, the complexity time has been allowed to depend on the total number of sensors in the network, focusing in other criteria first.

The procedure of head selection is the following:

- 1) Each node in the central area with remaining energy above a predefined threshold sets a random back off time;
- 2) When the first node whose back off time elapses, it broadcasts a head message to announce that it wins the CH selection;
- 3) Other nodes receiving this message cancel their back off time.

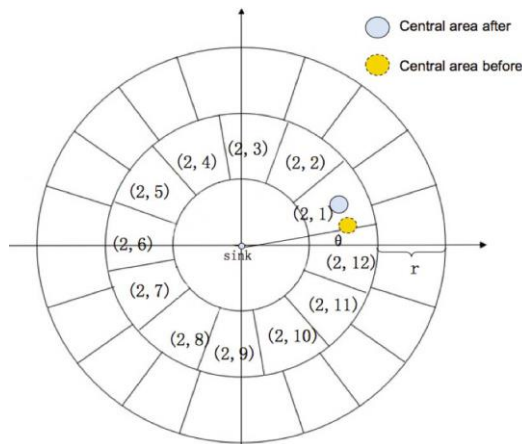


Fig. 3. Cluster shift for repartition.

FAN-SHAPED CLUSTERING

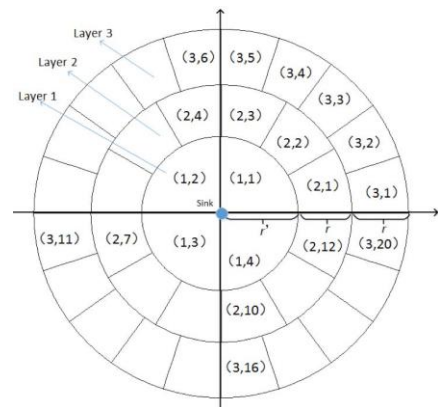


Fig 4 Fan Shaped Clustering

D. Routing Process

Routing is the process of selecting best paths in a network. In the past, the term routing also meant forwarding network traffic among networks. However, that latter function is better described as forwarding. Routing is performed for many kinds of networks, including the telephone network (circuit switching), electronic data networks (such as the Internet), and transportation networks. novel routing algorithm which combines with hierarchical routing and geographical routing is proposed. Based on the hierarchical network architecture, the process of forwarding packets between the source nodes in the target region and the base station consists of two phases-inter-cluster routing and intra-cluster routing, a greedy algorithm is adopted in the process of the inter-cluster routing and an multi-hop routing algorithm based on the forwarding restriction angle is designed for the intra- cluster routing. The analysis and simulation results show that our routing algorithm has better performance in terms of energy consumption and delay, it is suitable for the data transmission in a high-density wireless sensor network.

The routing protocols that have been proposed for sensor networks can be broadly classified as flat and hierarchical protocols. Hierarchical protocols organize the network nodes into several logical levels. This is typically implemented by a process called cluster formation. A cluster consists of a set of geographically proximal sensor nodes; one of the nodes serves as a cluster head. The cluster heads can be organized into further hierarchical levels. The key advantage of hierarchical routing protocols is that the cluster heads can perform efficient in-network data aggregation. Routing proceeds by forwarding packets up the hierarchy until the sink node is reached. Flat routing protocols, on the other hand, attempt to find good-quality routes from source nodes to sink nodes by some form of flooding. Since flooding is a very costly operation in resource starved networks, smart routing algorithms restrict the flooding to localized regions.

E. Performance Analysis

- Analyze the performance of FSC's basic behavior based on the number of alive nodes, total residual energy and packet collection rate.

Our works are based on the following assumptions:

- The sensor nodes are uniformly and independently distributed in a sensor field;
- All sensor nodes have the same fixed transmission power and transmission rate;
- Each sensor node is aware of its polar coordinate to the sink node, which can be obtained via attached GPS or some other sensor localization techniques [16];
- Three types of nodes are defined in our proposition ,i.e. cluster head, relay node, and member node. These nodes can change roles during lifetime.

Our solution addresses clustering of large-scale WSNs. The network field is partitioned into fan-shaped clusters as illustrated in Fig. 4. In this partition, we assume that the sink node is located at the center of the network. Then, the network field is partitioned into concentric layers (rings). The width of layers, except the first layer, is equal and denoted as r . As described above, the size of clusters in the first layer should be set larger than r in order to address hotspot issue, but how to exactly calculate this value is out of the scope of this paper. We just denote it as r_0 . Each layer is then divided into clusters with equal size. The equal-sized clusters have the same expected node number for randomly distributed case, so it can achieve load balancing. To do equal-sized clustering, the i th layer should be divided into $(2i - 1) * n$ clusters, where n is a natural number. In our work, n is set to 4. With this setting, the cluster form is more like a square, not too flat or narrow. This makes the CHs located in the central area have the minimum expected distance to its members.

$$d_{X-Y} = \sqrt{[r(i-1)]^2 + [r(i+1)]^2 - 2r^2(i-1)(i+1)\cos(\frac{i\pi}{2i-1})}$$

$$i \geq 1 \quad (1)$$

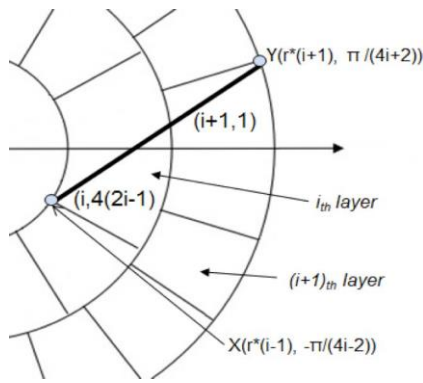


Fig. 5. Cluster shift for repartition

The value for cluster size which impacts the network performance should be defined carefully. Most of the previous works set the size of cluster by considering a node’s coverage radius. That is, the size is set so any node such that it can cover not only its own cluster, but all its neighbor clusters as well. For instance, Srikanth and Kumar [20] set the square cluster length l as: $l = R/\sqrt{8}$, where R is node’s coverage radius. This setting ensures that a node wherever it locates in a cluster can always communicate with the nodes in its neighbor clusters. This condition should also be granted in our proposition, so the layer i can always communicate with inner layer $i - 1$. This makes sure any node in a cluster can relay packets to inner-layer, and eventually arrive at the sink.

For this end, we calculate the maximum distance (distance $X-Y$) between two adjacent clusters. From Fig. 4, we observe that this maximum distance is between the last cluster of layer i and the first cluster of layer $i + 1$. For simplicity reason, we derive the polar coordinates of X, Y by considering r, r' , so the coordinates are $X(r(i-1), -\pi/(4i-2)), Y(r*(i+1), \pi/(4i+2))$. Then the distance between X and Y is calculated by equation (1). By solving this equation, we obtain when $i = 3$, d_{X-Y} has the maximum value:

$$d_{X-Y} = r * 3.7318 \tag{2}$$

Since node’s transmission radius should be at least equal to d_{X-Y} to guarantee that any node in two adjacent clusters can communicate to each other, we obtain the width of layers:

$$r = d_{X-Y} |_{i=3} = 3 * 3.7318 = R / 3.7318 \tag{3}$$

where R is the node’s transmission radius.

The partition procedure is as follows:

- 1) The sink broadcasts a partition message. This message includes the parameters r, r' , the sink’s position, the size of central area (see below), etc.
- 2) Each node receiving this message calculates to which cluster it belongs based on its position information and the received information.

IV. SIMULATION AND PERFORMANCE DISCUSSION

The proposed mechanism is analyzed by MATLAB simulation. The network field is defined as a circular area where nodes are randomly deployed. The sink is assumed to be located at the center of the area. We let each node send

one data packet every 1 second (one round). Other parameters are listed in Table I. The node’s transmission radius is set to 150m, so according to equation 3 the width of layer r is set to 40m. For simplicity reason, r is also set to 40m. Two propagation models that are used in the simulation are free space model and two-ray ground propagation model [18].

The performance analysis is based on three criteria: alive node number, total residual energy and packet collection rate. Alive node number is the total number of nodes which have not yet depleted their energy. Total residual energy is the total energy of all alive nodes. Packet collection rate for each round is defined as the number of actual received packets by the sink divided by the total number of nodes. The last criterion is important, since it considers both the number of dead nodes and packet loss. Packet loss happens in two scenarios:

- 1) No node can be selected as CH in a cluster. All members have to discard the generated data;
- 2) When a relay cannot find any other relays to continue packet forwarding, all aggregated packets received/generated by this relay are discarded.

In the following, each simulation is executed 10-20 times. Then the mean value is used for performance analysis.

A. FSC Behavior Analysis

Let us first analyze some basic behavior of FSC. Fig. 6 represents total alive nodes, total residual energy and the packet collection rate with respect to the time. Fig. 6.a shows that the total number of alive nodes decreases with the time. We observe that no node dies until 600 sec later and many nodes start to die about 1300 sec later. The reason for the latter phenomenon is that nodes consume the energy evenly, so some of them start to die almost at the same time. Both observations demonstrate that our proposition achieves good load balancing. The phenomenon is also observed in Fig. 6.b where the total residual energy decreases with the time and this decrease rate is slow at first then accelerated after 1300 sec. The acceleration phenomenon is caused by two factors. One is, after some nodes’ death, packets need to find a long route to arrive at the sink. The other is the re-clustering process which is executed more frequently. In both cases energy is consumed more quickly. Fig 6.c shows the packet collection rate with respect to the time. We observe that until 1000 sec, the packet collection rate is almost 100%. However, about 1000 sec later, this rate decreases quickly. We explain this phenomenon later. But we also observe that, even 2000 sec later, the collection rate is still above 5%. This means that there are still active nodes in the first layer (the hotspot area).

This also demonstrates that FSC achieves load balancing. In the following, we analyze how the parameters, e.g. central area radius, threshold for CH, and relay selection, impact the performance. Since the packet collection rate is the most important criterion, it is chosen for this analysis. As mentioned above, if the central area radius is defined too small, the probability of failing to select a CH in a cluster is high. This of course decreases the data collection rate. While if the value is set too large, intra-communication cost may not be minimized, since nodes not located near to the center could be selected as CH.

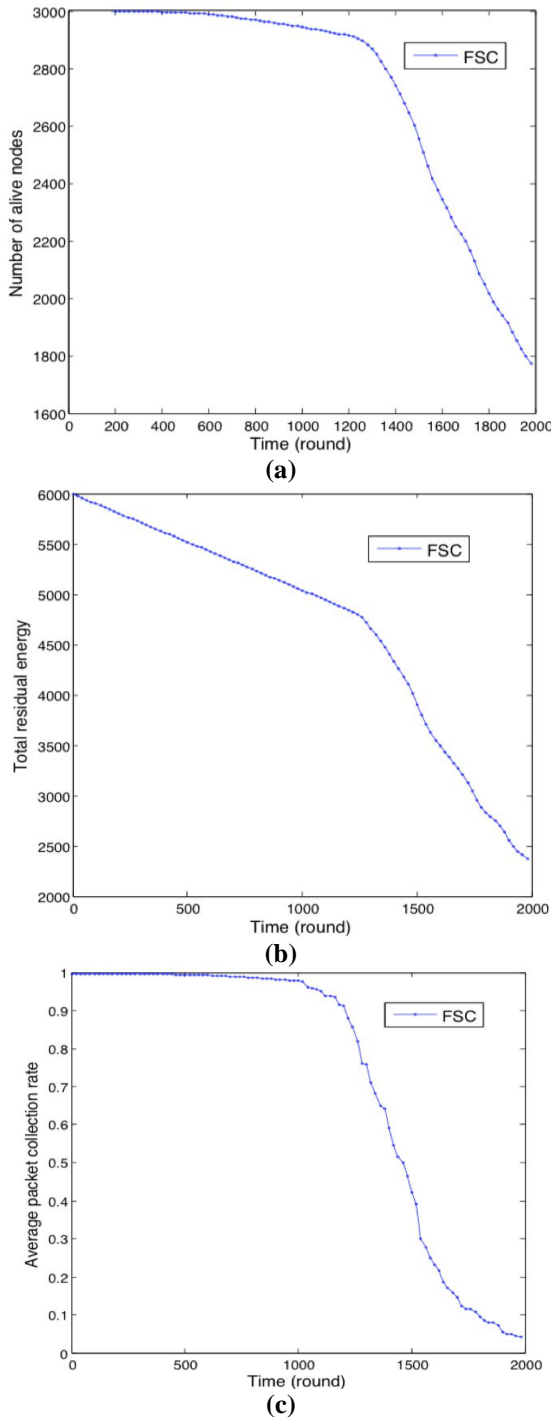


Fig. 6.FSC's basic behavior. (a) Analysis on number of alive nodes. (b) Analysis on total residual energy. (c) Analysis on packet collection rate.

CONCLUSION:

In order to increase the network longevity, Fan-Shaped Algorithm is proposed and implemented in this paper. In this algorithm optimal distance based transmission strategy was proposed on the basis of Ant Colony Optimization methods. This optimal distance based strategy is implemented for high energy efficiency, good energy balancing and also it achieves minimal energy utilization of nodes with maximal energy consumption for the entire network. A detailed evaluation with simulations on Matlab of FSC clustering

protocol is addressed. And it has been deduced from the analysis of number of alive nodes, total residual energy and packet collection rate FSC performs efficiently and improves network lifetime.

REFERENCES

1. Y. Wei, J. Heidemann, and D. Estrin, "Medium access control with coordinated adaptive sleeping for wireless sensor networks," *IEEE/ACM Trans. Netw.*, vol. 12, no. 3, pp. 493–506, Jun. 2004.
2. M. Al-Jemeli and F. A. Hussin, "An energy efficient cross-layer network operation model for IEEE 802.15.4-based mobile wireless sensor networks," *IEEE Sensors J.*, vol. 15, no. 2, pp. 684–692, Feb. 2015.
3. N. A. Pantazis, S. A. Nikolidakis, and D. D. Vergados, "Energy-efficient routing protocols in wireless sensor networks: A survey," *IEEE Commun.Surv.Tuts.*, vol. 15, no. 2, pp. 551–591, Second Quarter 2013.
4. C. Karakus, A. C. Gurbuz, and B. Tavli, "Analysis of energy efficiency of compressive sensing in wireless sensor networks," *IEEE Sensors J.*, vol. 13, no. 5, pp. 1999–2008, May 2013.
5. M. A. Youssef, A. Youssef, and M. F. Younis, "Overlapping multihop clustering for wireless sensor networks," *IEEE Trans. Parallel Distrib.Syst.*, vol. 20, no. 12, pp. 1844–1856, Dec. 2009.
6. O. Younis, M. Krunz, and S. Ramasubramanian, "Node clustering in wireless sensor networks: Recent developments and deployment challenges," *IEEE Netw.*, vol. 20, no. 3, pp. 20–25, May/June 2006.
7. J. N. Al-Karaki and A. E. Kamal, "Routing techniques in wireless sensor networks: A survey," *IEEE Wireless Commun.*, vol. 11, no. 6, pp. 6–28, Dec. 2004.
8. O. Boyinbode, H. Le, A. Mbogho, M. Takizawa, and R. Poliah, "A survey on clustering algorithms for wireless sensor networks," in *Proc. 13th Int. Conf. Netw.-Based Inf. Syst. (NBIS)*, 2010, pp. 358–364.
9. W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks," *IEEE Trans. Wireless Commun.*, vol. 1, no. 4, pp. 660–670, Oct. 2002.
10. M. Ye, C. Li, G. Chen, and J. Wu, "EECS: An energy efficient clustering scheme in wireless sensor networks," in *Proc. 24th IEEE IPCCC*, Apr. 2005, pp. 535–540.
11. O. Younis and S. Fahmy, "HEED: A hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks," *IEEE Trans. MobileComput.*, vol. 3, no. 4, pp. 366–379, Oct.-Dec. 2004.
12. G. Chen, C. Li, M. Ye, and J. Wu, "An unequal cluster-based routing protocol in wireless sensor networks," *Wireless Netw.*, vol. 15, no. 2, pp. 193–207, Feb. 2009.
13. A. Thakkar and K. Kotecha, "Cluster head election for energy and delay constraint applications of wireless sensor network," *IEEE Sensors J.*, vol. 14, no. 8, pp. 2658–2664, Aug. 2014.
14. Y. Liao, H. Qi, and W. Li, "Load-balanced clustering algorithm with distributed self-organization for wireless sensor networks," *IEEE Sensors J.*, vol. 13, no. 5, pp. 1498–1506, May 2013.
15. M. Tarhani, Y. S. Kaviani, and S. Siavoshi, "SEECH: Scalable energy efficient clustering hierarchy protocol in wireless sensor networks," *IEEE Sensors J.*, vol. 14, no. 11, pp. 3944–3954, Nov. 2014.
16. K. Yedavalli and B. Krishnamachari, "Sequence-based localization in wireless sensor networks," *IEEE Trans. Mobile Comput.*, vol. 7, no. 1, pp. 81–94, Jan. 2008.
17. B. Yan, X. Zhou, H. Wang, and B. Li, "A grid-based clustering method for large-scale wireless sensor networks," in *Proc. ICCAS*, 2007, pp. 414–418.
18. R. Xie and X. Jia, "Transmission-efficient clustering method for wireless sensor networks using compressive sensing," *IEEE Trans. Parallel Distrib. Syst.*, vol. 25, no. 3, pp. 806–815, Mar. 2014.
19. J. Baek, S. K. An, and P. Fisher, "Dynamic cluster header selection and conditional re-clustering for wireless sensor networks," *IEEE Trans. Consum. Electron.*, vol. 56, no. 4, pp. 2249–2257, Nov. 2010.
20. [20] S. Jannu and P. K. Jana, "Energy efficient grid based clustering and routing algorithms for wireless sensor networks," in *Proc. 4th Int. Conf. CSNT*, 2014, pp. 63–68