Node Probability based Clustering Approach for Energy Efficient Routing in Wireless Sensor Network

Diwa kumari sinha, Er. Varsha Mishra, Er. Harish Patidar
Department of Computer Science Department of Information Technology Department of Computer Science
Lakshmi Narain College of Technology,Indore Madhya Pradesh, Indore

Abstract *- Wireless sensor networks are application specific networks composed of large number of sensor nodes. Limited energy resource of sensor nodes make efficient energy consumption of nodes as main design issue. Energy efficiency is achieved from hardware level to network protocol levels. Clustering of nodes is an effective approach to reduce energy consumption of nodes. Clustering algorithms group nodes in independent clusters. Clustering algorithms prolong network lifetime by avoiding long distance communication of nodes to base station. Design of an energy efficient cluster based protocol for WSNs becomes more important for prolonging the network life time. In this paper we propose probability based clustering approach for energy efficient routing protocol. In this context the energy targeted QoS parameters are selected for performance measurement. So the results demonstrated that proposed mechanism is very effective of clustering in WSN.*

Keywords: *Wireless Sensor Network, Clustering, Energy, QoS, NS2, Cluster head, network node*

I. INTRODUCTION

Networking a large number of wireless devices in ad hoc mode will facilitate a wealth of applications not feasible under the conventional base station-to-network node communication model. Wireless sensor networks consist of hundreds to thousands of low-power multifunctioning sensor nodes, operating in an unattended environment, with limited computational and sensing capabilities. Recent developments in low-power wireless integrated microsensor technologies have made these sensor nodes available in large numbers, at a low cost, to be employed in a wide range of applications in military and national security, environmental monitoring, and many other fields [1]. Data gathering is a common but critical operation in many applications of wireless sensor networks. Innovative techniques that improve energy efficiency to prolong the network lifetime are highly required. Clustering is an effective topology control approach in wireless sensor networks, which can increase network scalability and lifetime. The potential applications of WSNs are highly varied, such as environmental monitoring, target tracking and military surveillance [2].

A. Wireless Sensor Network

The concept of wireless sensor networks is based on a simple equation:

Sensing + CPU + Radio = Thousands of Potential Applications

As soon as people understand the capabilities of a wireless sensor network, hundreds of applications spring to mind. It seems like a straightforward combination of modern technology. However, actually combining sensors, radios, and CPU's into an effective wireless sensor network requires a detailed understanding of the both capabilities and limitations of each of the underlying hardware components, as well as a detailed understanding of modern networking technologies and distributed systems theory. Each individual node must be designed to provide the set of primitives necessary to synthesize the interconnected web that will emerge as they are deployed, while meeting strict requirements of size, cost and power consumption. A core challenge is to map the overall system requirements down to individual device capabilities, requirements and actions. To make the wireless sensor network vision a reality, architecture must be developed that synthesizes the envisioned applications out of the underlying hardware capabilities [3].

B. Clustering

Clustering has proven to be an efficient method that increases the network life time by dropping the energy utilization and provides the necessary scalability. To achieve high scalability and increased energy efficiency and to enhance the network life time the researchers have highly adopted the scheme of forming clusters i.e.

grouping the sensor nodes in large scale wireless sensor network environments

Clustering means a way to reconfigure all nodes into small virtual groups according to their regional locality and is defined as Cluster Head and cluster member that are determined with the same rule. Every clustering algorithm consists of two mechanisms, cluster formation and cluster maintenance. In cluster formation, cluster heads are selected among the nodes to form clusters.

Cluster Head is the node which manages the cluster activities like managing cluster process, updating routing table, discovery of new routes. The nodes other than the Cluster Head inside the cluster are called Ordinary Nodes (ON). Nodes having interred cluster links which can communicate with more than one cluster are called Gateway Nodes (GN). If the destination is inside the cluster, ordinary nodes send the packets to their cluster head that distributes the packets inside the cluster, or if to be delivered to other cluster then forward them to a gateway node. In such way, only cluster heads and gateways take part in the propagation of routing update or control [4, 5].

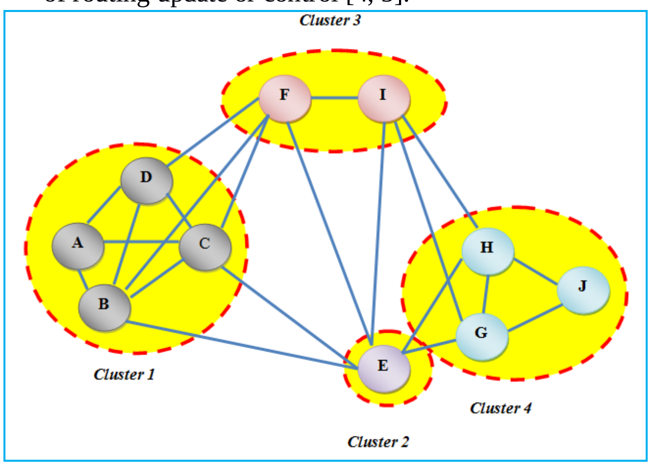

Figure 1: Clustering

II. LITERATURE SURVEY

The given section introduces the different techniques and methods that are recently developed for optimizing the solutions for effective energy efficient clustering scheme for maximum network utilization. These techniques are helps to develop an effective methodology for proposed concept.

Dali Wei et al. [6] proposes a distributed clustering algorithm, Energy-efficient Clustering (EC) that determines suitable cluster sizes depending on the hop distance to the data sink, while achieving approximate equalization of node lifetimes and reduced energy consumption levels. Authors additionally propose a simple energy-efficient multi-hop data collection protocol to evaluate the effectiveness of EC and calculate the end-to-end energy consumption of this protocol; yet EC is suitable for any data collection protocol that focuses on energy conservation. Performance results demonstrate that EC extends network lifetime and achieves energy equalization more effectively than two well-known clustering algorithms, HEED and UCR.

K. Ferens et al. [7] presented improving the energy efficiency of clustering algorithms for wireless sensor networks. The first method uses a single parameter, residual energy, to determine cluster head suitability in a passive cluster head election process; this is intended for energy constrained applications. Second, gateway nodes are allowed to distribute their sensor readings across different cluster heads, to better balance the service load. Third, this paper shows that up to a maximum of six new re-elections may only be required due to a single cluster head resignation, and, therefore, the algorithm is scalable. Forth, a sensing window is applied in TDMA slots to improve the energy efficiency of intra-cluster communications. MATLAB simulations show that the proposed algorithm has longer lifetime than basic passive clustering, and has improved intra-cluster communications scheduling (i.e., better energy efficiency).

In this paper, ***Shio Kumar Singh et al. [8]*** propose a new approach of an energy-efficient homogeneous clustering algorithm for wireless sensor networks in which the lifespan of the network is increased by ensuring a homogeneous distribution of nodes in the clusters. In this clustering algorithm, energy efficiency is distributed and network performance is improved by selecting cluster heads on the basis of (i) the residual energy of existing cluster heads, (ii) holdback value, and (iii) nearest hop distance of the node. In the proposed clustering algorithm, the cluster members are uniformly distributed and the life of the network is further extended.

Energy efficient clustering and routing are two well-known optimization problems which have been studied widely to extend lifetime of wireless sensor networks (WSNs). ***Pratyay Kuila et al. [9]*** presents Linear/ Nonlinear Programming (LP/NLP) formulations of these problems followed by two proposed algorithms for the same based on particle swarm optimization (PSO). The routing algorithm is developed with an efficient particle encoding scheme and multi-objective fitness function. The clustering algorithm is presented by considering energy conservation of the nodes through load balancing. The proposed algorithms are experimented extensively and the results are compared with the existing algorithms to demonstrate their superiority in terms of network life, energy consumption, dead sensor nodes and delivery of total data packets to the base station.

Typically, a wireless sensor network contains an important number of inexpensive power constrained sensors, which collect data from the environment and transmit them towards the base station in a cooperative way. Saving energy and therefore, extending the wireless sensor networks lifetime, imposes a great challenge. Clustering techniques are largely used for these purposes. In this paper, ***Brahim Elbhiri et al. [10]*** propose and evaluate a clustering technique called a Developed Distributed Energy Efficient Clustering scheme for heterogeneous wireless sensor networks. This technique is based on changing dynamically and with more efficiency the cluster head election probability. Simulation results show that our protocol performs better than the Stable Election Protocol (SEP) by about 30% and then the Distributed Energy-Efficient Clustering (DEEC) by about 15% in terms of network lifetime and first node dies.

III. PROPOSED WORK

In order to save the energy consumption of WSN, a clustering approach for WSN has been considered. In the approach, N sensor nodes are divided into clusters, and each cluster has a representative sensor node called cluster head (CH). Each non-CH sensor node sends the sensed data to the CH node in its own cluster, instead of to BS. Each CH node aggregates the received data into smaller size and sends it to BS.

The proposed clustering algorithm includes the following three main phases for completing the clustering on the network.

- ✓ **Parameter selection:** In this phase the node QoS parameters are selected for performing the probability computation.
- ✓ **Node Probability Computation:** In this phase the probability of the all nodes are computed and their exchange is performed for selecting the best node among the available nodes.
- ✓ **CH election:** In this phase the cluster head is elected to serve their cluster members.

A. Parameter Selection

The key objective of the proposed clustering technique is to regulate the energy consumption in the network. Therefore the following key properties are selected for solution development purpose.

- ✓ **Remain Energy:** Remain energy of a node indicate their energy efficiency, additionally their life time to be live. Energy less than a predefined threshold can affect the normal functioning of network. Therefore in order to serve the network longer it is required the cluster head node has the sufficient energy level. According to the definition of energy consumption the difference of two time based energy level is used for computing the energy consumption rate which is used for cluster head selection. Thus suppose at time t_1 the node have the energy $E_1$and after a time difference Δt the new energy level becomesE_2. Then the rate in change on energy can be computed using the following formula;

$$\Delta E = E_1 - E_2$$

- ✓ **Buffer Length:** The buffer or queue length of a node demonstrates the amount of workload which is processed by any node. In this context the amount of buffer length is free to use indicate the node if free and can able to serve better the cluster members. This here for the length of buffer the letter B is used.
- ✓ **Signal Strength Power:** The signal strength of a node shows the transmission power ability thus for more optimal node selection the signal strength of the node is used. The signal strength of the node can be represented using the letter S for further discussion.

B. Probability Computation

In order to select most optimal cluster head from the available cluster members the normalization process is required to compute the probability. Therefore the probability computation required some additional coefficients for computing probability factor. The probability computation is performed by all the nodes in network. To compute the probability the following formula is used:

$$P = 0.5 * \Delta E + 0.25 * B + 0.25 * S_S$$

Where, $\Delta E, B, S$are the weight coefficient for normalizing the weights, the coefficients can be selected by the designer according to the following condition:

$$\Delta E + B + S_S = 1$$

In this scenario, we need to reform the network using selection of the CH by which procedure of the clustering performing and produces result on the basis of selected output parameter.

To choose the cluster head, in each round, each node chooses a random number between 0 and 1. If the number is less than a threshold, the node becomes a cluster-head for the current round. The threshold $\alpha_{threshold}(n_i)$ for the node n_i is defined as in following equation.

$$\alpha_{threshold}(n_i) = \begin{cases} \frac{p}{1-p\left(rmod\frac{1}{p}\right)} if n_i \in G \\ 0 Otherwise \end{cases}$$

C. Proposed Algorithm

The entire process of the cluster head selection approach can be summarized as the algorithm the table 3.1 shows the process of the proposed algorithm:

Table 1: CH election Algorithm

Input: Number of Nodes
Output: Cluster head Selection

1: A Node in Network Broadcast the Clustering Request
2: Wait for Response Generated by Network
5: Calculate Different Thresholding Parameter

i. Energy ΔE
ii. Signal Strength S_S
iii. Buffer B

6: for each round calculate node probability P

$$P = 0.5 * \Delta E + 0.25 * B + 0.25 * S_S$$

7: For each Round Compute Threshold $\alpha_{threshold}$

$$\alpha_{threshold}(n_i) = \begin{cases} \frac{p}{1-p\left(rmod\frac{1}{p}\right)} if n_i \in G \\ 0 Otherwise \end{cases}$$

8: For i of all node

9: Generate Random Number R_i of each node
10: Compare Random Number and Threshold Value

11:$if(R_i < \alpha_{threshold})$

12: Node as a Cluster head

13:$else$

14: repeat from step **10**

15:$endif$

16: Node that are cluster head from R_i cannot be a cluster head for all next round

IV. IMPLEMENTATION

The simulation is being implemented in the Network simulator [11]. Protocol used here is AODV.

Table 2: Simulation Scenarios

Parameters	***Values***
Antenna Model	Omni Antenna
Dimension	1000X1000
Radio-Propagation	Two Ray Ground
Channel Type	Wireless Channel
Traffic Model	CBR
Routing Protocol	AODV
Mobility Model	Random Waypoint

Simulation of AODV based ECC Approach: In this phase the network is configured with the help of AODV of base approach of energy efficient clustering routing protocol and with the different number of nodes the experiments are performed. During the experiments different performance parameters are computed and their comparative study is performed with proposed approach. The traditional network is demonstrated using figure 2.

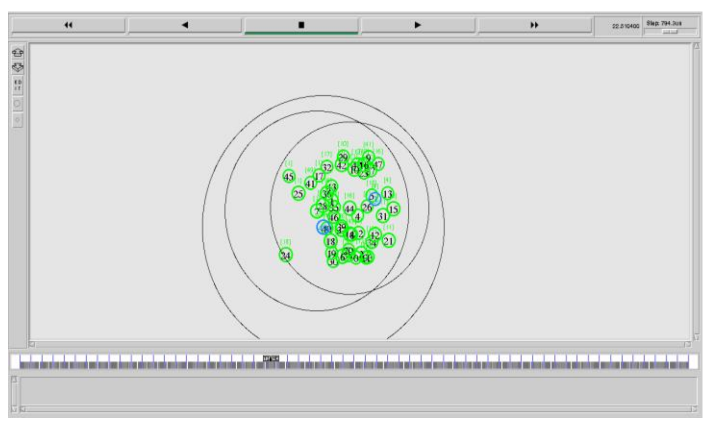

Figure 2: ECC Approach

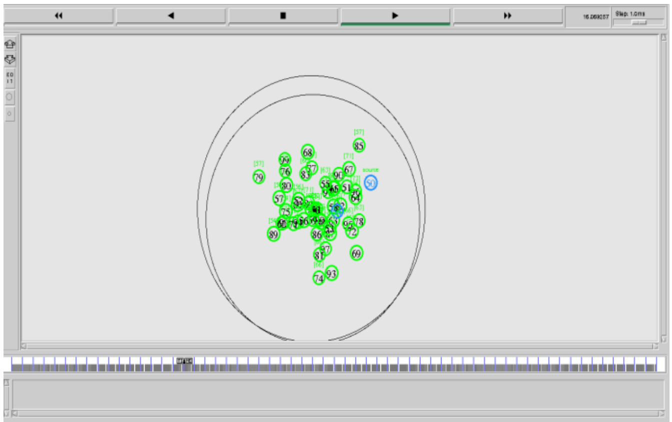

Figure 3: Proposed Approach

Simulation of Proposed Clustering Based Network: In this phase the network is configured with the help of proposed cluster based routing technique and their performance is projected for comparative performance study. The required network is demonstrated using figure 3.

V. RESULT ANALYSIS

A. End to End Delay

End to end day on network refers to the time taken, for a packet to be broadcast across a network from resource to purpose device, this delay is calculated using the beneath given formula.

$$E2EDelay = ReceivingTime - SendingTime$$

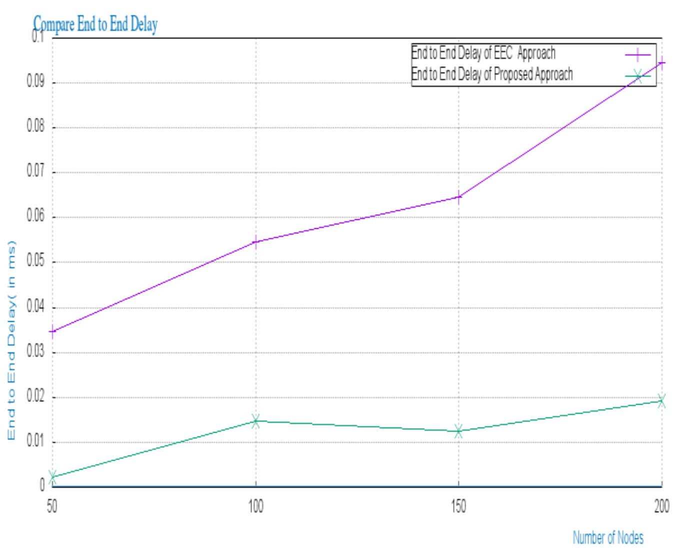

Figure 4: End to End Delay

The end to end delay of the proposed technique and traditional AODV routing is reported in figure 4. In this diagram the X axis shows the number of network nodes in the experiments and the Y axis shows the amount of end to end delay in terms of milliseconds. The results show the end to end delay of the network in traditional ECC is higher as compared to the proposed cluster based routing. Therefore the proposed technique is much adoptable as compared to the traditional approach. Additionally the increasing amount of network nodes is impact on end to end delay. In other words the end to end delay increases with the increasing amount of network nodes.

B. Consumed Energy

During the communication and network events the nodes consumes a part of energy from its initial amount of energy. The consumed energy of network nodes are recorded and reported here as the performance parameter of network.

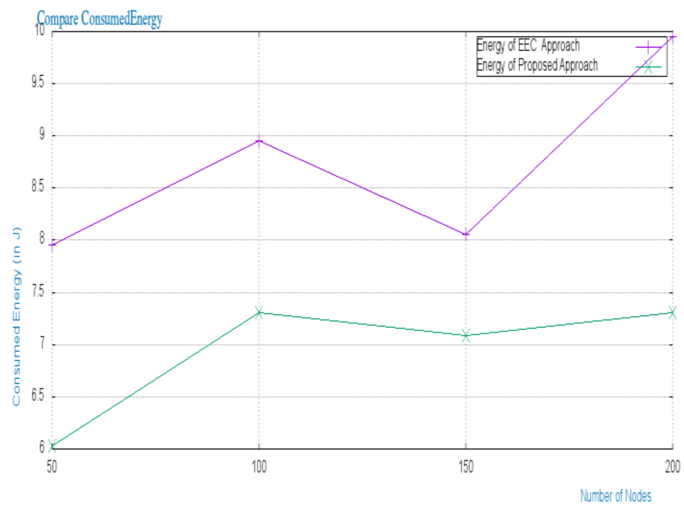

Figure 5: Consumed Energy

The figure 5 shows the amount of energy consumed in network nodes during the different experiments. The experiments are performed over 50, 100, 150 and 200 numbers of nodes. In order to demonstrate the performance of networks the X axis contains the number of nodes in experimental network and the Y axis shows the amount of energy consumed after experiments. The measurement of energy is given here in terms of Jules. According to the experimental results the proposed technique of energy efficient clustering consumes less amount of energy as compared to the traditional ECC scheme. Therefore the proposed approach of clustering is energy efficient as compared to normal network configurations.

C. Packet Delivery Ratio

The Packet delivery ratio is also termed as the PDR ratio. The packet delivery ratio provides information about the performance of any routing protocols using the successfully delivered packets to the destination. The PDR can be computed using the following formula:

$$PacketDeliveryRatio = \frac{TotalDeliveredPackets}{TotalSentPackets}$$

The comparative packet delivery ratio of traditional ECC routing and clustering based technique is described using figure 6. In this diagram the different number of nodes are given in X axis and the Y axis includes the percentage amount of packets successfully delivered. According to the obtained results the proposed technique able to deliver more packets effectively as compared to the traditional ECC method. Additionally that shows 89-92% percentage amount of successfully delivered packets. Therefore the proposed technique is more effective as compared to the traditional method. On the other hand the traditional approach shows the 79-81% of successfully delivered packets. Thus the proposed approach is more efficient than the traditional routing technique.

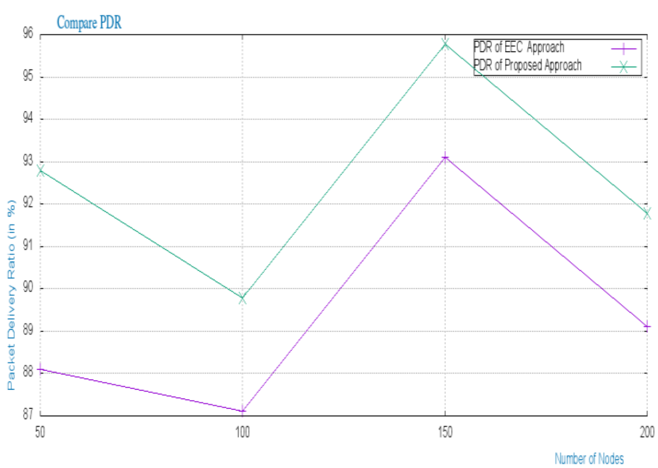

Figure 6: Packet Delivery Ratio

D. Routing Overhead

The routing overhead is the amount of additional control messages exchanged in network. The routing overhead is responsible to the network de-efficiency. The amount of routing overhead for both the network routing techniques is given using figure 7. In this diagram the amount of nodes in network is given using X axis and the Y axis contains the routing overhead of the network. According to the experimental results the proposed cluster based routing technique produces less routing overhead as compared to the base ECC method thus proposed technique much suitable for improving other network performance parameters. The main reason behind less routing overhead is the clustering approach by which the addressing and mapping of the location needs less amount of control message exchange in the proposed routing technique.

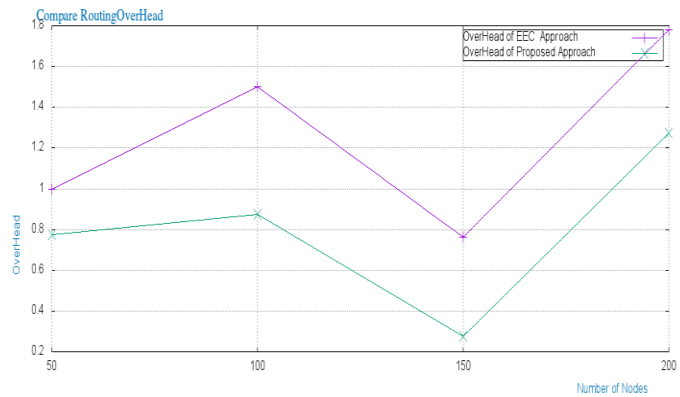

Figure 7: Routing Overhead

E. Throughput

Network throughput is the regular rate of successful message delivery above a communication channel. This data might be delivered above a physical or logical link, or pass during a certain network node. The throughput is regularly considered in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot. The comparative performance of the traditional ECC routing and proposed energy efficient routing technique is demonstrated using figure 8. In this diagram the amount of experimental nodes are given in X axis and the Y axis contains the amount of throughput achieved in the network. The computed throughput of network is reported here in terms of KBPS (kilobyte per seconds). According to the obtained performance results the proposed technique enable higher throughput as compared to the traditional routing technique thus proposed technique of clustering more efficient than the traditional routing technique.

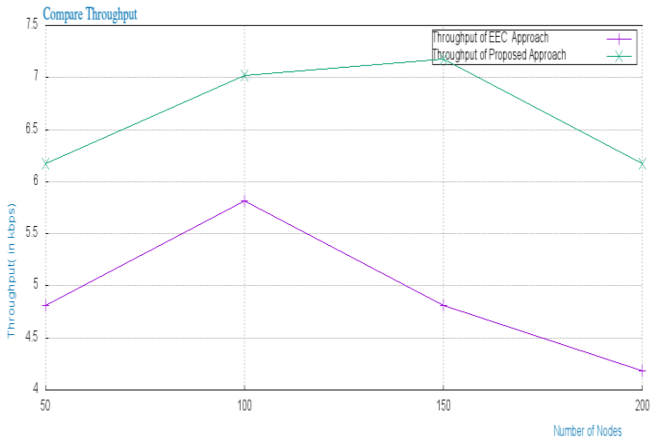

Figure 8 Throughput

VI. CONCLUSION

Wireless sensor networks (WSNs) have attracted significant attention over the past few years. A growing list of civil and military applications can employ WSNs for increased effectiveness; especially in hostile and remote areas. Examples include disaster management, border protection, combat field surveillance. In these applications a large number of sensors are expected, requiring careful architecture and management of the network. Grouping nodes into clusters has been the most popular approach for support scalability in WSNs. The theme of the research work is centered on Energy efficiency which is an important aspect of WSNs. The limited energy source of the sensor nodes calls for design of energy efficient schemes. Cluster based techniques were found energy efficient. In this research work, various energy efficient schemes has proposed for cluster based sensor networks. WSNs can increase the energy efficiency by using an appropriate clustering algorithm for combination of sensor nodes. The proposed mechanisms are more suitable and optimal for increasing the lifetime of WSNs in clustered structure

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