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An Energy Efficient Routing method for improving Network lifetime with proper uniform routing strategies in Wireless Sensor Networks with Centered Base station

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Abstract:
During the development and use of wireless sensor networks (WSNs), different routing protocols have been proposed in different studies. The protocols come with varying features regarding their clustering probabilities and thresholds. Indeed, most of the proposed models have proved superior in such a way that they have extended the network lifetime of the systems to which they have been applied. Despite this positive trend, however, the models have been associated with non-uniformity in the various networks' epochs. With the nodes' sectors divided in the networks, especially with the aim of optimizing energy consumption, a factor that has determined how sensor nodes and base stations communicate via a clustering approach or directly has been that which entails distance. To ensure that the problem of cluster non-uniform division is overcome, the network needs to be segmented to obtain fixed sectors in the entire network lifetime. Indeed, the latter arrangement translates into a reduction in the average distance of data transmission. Also, in the respective regions, the selection of cluster heads does not rely on other regions, implying that each zone has a cluster head. For center base stations in the target zones, the EERACBSH and EERACBS models are proposed. For the case of LEACH, it also exhibits horizontal segmentation and seeks to achieve energy efficiency in each region. Outside the regions, especially with heterogeneous and homogeneous networks, EEMCRPH and EEEMCRP algorithms have been proposed, respectively. In this study, findings from the simulation suggest that the proposed model extends the network lifetime of the system, outperforming other algorithms with which it has been compared. Hence, the technique reflects a superior routing protocol that strives to improve on the outcomes that have been associated with other routing frameworks that have been proposed and implemented by other researchers.

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Abbreviations:

EERACBS - Energy efficient Routing algorithm for Centered Base Station

EERACBSH - Energy efficient Routing algorithm for Centered Base Station for heterogeneous networks

ZEEL - Zonal Energy efficient LEACH

EEEMCRP - Energy Efficient Multi clustered Routing Protocol for Homogeneous networks

EEMCRPH - Energy Efficient Multi clustered Routing Protocol for Heterogeneous networks

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I. INTRODUCTION

Sensor networks refer to energy-constrained and low-power node arrangements constituting wireless and memory communication electronics, processors, and sensors [1, 2]. Also, lightweight batteries are used to power the sensor nodes. Indeed, sensor node capability tends to be limited but when a sensor network is developed, significant tasks can be accomplished via a collaborative approach in which many nodes are used to form a dense sensing field [3]. Indeed, the motivation behind such arrangements lies in the criticality of establishing clustering arrangements through which certain sensor node burdens could be addressed. Hence, the selection criterion deemed ideal has been that which strives to ensure that cluster nodes selected are those exhibiting the least threshold values in the WSN, a step poised to realize energy efficiency during fault tolerance, load-balancing, and data gathering [4]. Notably, the nodes could play the role of cluster heads, especially when hierarchical sensor networks are established [5]. However, it is also worth indicating that cluster heads are limited in a similar fashion as sensor nodes whereby they are power-constrained because they are operated by batteries.

With cluster node power depletion, network functionality tends to be affected severely. Therefore, it is important to ensure that the data communication's total load is well distributed relative to the other cluster nodes. This process, based on the literature, tends to extend the cluster heads' lifetime [6], rather than only extend the lifetime of individual sensor nodes. It is also notable that when a proper clustering system is developed, it could aid in the effective load balancing on various relay nodes. Similarly, most of the clustering approaches that have been proposed by the majority of the previous researchers rely on simple heuristics and they determine the relay node load based on the number of sensor nodes linked to the respective clusters [7]. A specific example is the case of single hop framework that ensures that there is a direct transmission by relay nodes to base stations. Whereas the decision to ensure that fewer nodes are assigned to the sensor nodes could prove efficient, focusing on clusters that are farther from base stations proves more effective compared to equal sensor node distributions among the selected clusters [8]. Hence, heuristic approaches fail to optimize the network lifetime, yet load balanced clustering is expected to realize this objective.

To address the problem of non-uniform clustering divisions, the proposed model strives to divide the network to obtain fixed regions in the entire WSN lifetime. Indeed, this arrangement is projected to minimize the average distance of data transmission. Also, the selected of cluster heads in this model is not affected by other regions because each region has its cluster head. The motivation of the study is to design a protocol through which network lifetime might be maximized upon implementation in routing schemes.

II. LITERATURE REVIEW

Sensor networks entail nodes that are energy-constrained and of low power, often equipped with wireless and memory communication electronics, as well as processors and sensors [1, 2]. To operate sensor nodes, lightweight batteries are used. Whereas there is limited performance for individual sensor nodes, sensor networks in the entirety can achieve bigger tasks because different nodes collaborate to form a dense sensing field [3].

The aim is to ensure that clustering schemes developed are those that minimize sensor node constraints. Hence, energy-efficient processes of load tolerance, load balancing, and energy efficiency have been realized through the focus on cluster nodes exhibiting optimum threshold values [4]. After being provided with higher energy, the nodes could act as cluster heads, especially when

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hierarchical sensor networks are used [5]. However, batteries are used to operate those cluster nodes, a power constraint outcome.

Indeed, power depletion affects network functionality severely. Hence, various protocols have been proposed to extend the network lifetime of cluster heads [6], rather than overemphasize the maximization of the lifetime of individual sensor nodes. Imperatively, proposer clustering schemes tend to balance the load effectively relative to the relay nodes. In the literature, most of the models that have been proposed employ simple heuristics, determining the relay node load based on the number of sensor nodes linked to the respective clusters [7]. A specific illustration is the case of the single hop arrangement in which the respective relay nodes transmit data directly to the expected base stations. Whereas sensor nodes in such arrangements tend to be distributed equally, an ideal option is that which ensures that when clusters are farther from base stations, they are assigned fewer sensor nodes [8].Similarly heuristics-based models do not assure optimum outcomes regarding network lifetime extension, yet load-balanced clustering seeks to achieve this objective.

Given that non-uniform division in clustering is worth addressing, this study proposes a model that divides a network into fixed regions in the entire WSN lifetime. The proposed mechanism seeks to ensure that the average distance of data transmission is reduced. Also, the selection of the cluster heads does not rely on other regions because each region exhibits its own cluster head. The central objective of the study lies in the realization of a system through which WSN routing schemes' network lifetime could be maximized.

III. MOTIVATION

In the literature, clustering arrangements that have been proposed have been those that consume less energy and emerge to be energy efficient, outperforming previous models. To optimize energy consumption, attributes that have been on the focus include relaying methods and threshold functions regarding the interplay between the base stations and sensor nodes. The role of cluster heads has been to distribute and divide the load uniformly across sensor nodes. The proposed algorithm seeks to support this function to ensure that energy consumption is minimized. At the beginning of the network, the assumed probability is the factor that determines the cluster head that is selected.

To address the limitation of the previous clustering protocols and ensure that there is uniform energy distribution relative to the distance of transmission between the base station and the sensor node, the proposed approach will ensure that there is equal sensor distribution in the network, with node transmission distances controlled easily. It is also notable that the location of the base station, either inside or outside the network, affects the WSN lifetime. Hence, the proposed method seeks to respond to the perceived weaknesses associated with previously proposed algorithms. The following section describes the proposed EERABCS energy efficient routing protocol.

IV. UNITS STANDARDIZED ROUTING FOR WIRELESS SENSOR NETWORKS

A. The Proposed EERABCS Algorithm for Homogeneous Networks

In the proposed model, the base station's location is at the network center and seeks to improve the network lifetime in terms of factors such as the number of cluster heads, network stability, and throughput. In a given sector, if most of the nodes are located far from the base station, more energy tends to be consumed during data transmission, translating into reduced network lifetime, as well as throughput. To address these issues, the proposed system divides the WSN network into sectors. Whereas Sector 1 and 3 follow the process of selecting cluster heads because they are located far away from the base station, Sector 2 communicates with the base station directly due to closer location to the base station. In the arrangement, there is a balance in energy consumption and the number of nodes is maximized wile reducing the distance of data transmission.

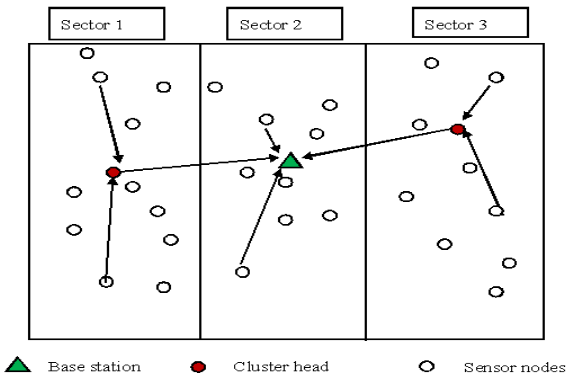

Fig. 1. Operation of EERACBS and EERACBSH

Also, nodes that are located closer to other sectors are expected to send data to the base stations directly. The base stations aggregate the data from the sensor nodes to the cluster heads. From the radio energy dissipation framework, the radio-expended energy in [18] aids in ensuring that during k-bit message transmission over a given distance d achieves the desired signal to noise ratio. The assumption is that the nodes are distributed uniformly. Also, it is expected that with the location of the sink occurring anywhere in the field, the distance between the sink and the node does not exceed d_o [19].

B. The proposed EERACBSH in heterogeneous networks

For a node to become a cluster head, it is expected that the number does not exceed the threshold. For the threshold that is introduced, the arrangement operates in such a way that each of the elements becomes a cluster head only once in every round. In this case, the cluster nodes' epoch is represented by the number of rounds in the whole WSN network. To achieve the cluster head number considered to be normal nodes in each of the epochs' rounds, the value becomes:

$n\ (1 - m)\ p_{nrml}$

C. The proposed ZEELfor homogeneous networks

Notably, the proposed ZEEL framework relies on two approaches for data transmission to the target base station. This arrangement could be likened to the operation of EERACBS model; whereby there is cluster head direct data transmission and communication. It is also notable that this arrangement reflects an extended version of Z-SEP algorithm because it applies to heterogeneous networks [15]. In Sector 2, it is expected that nodes transmit information directly to the base stations. Also, the nodes are expected to evaluate the surrounding and collect information of interest before relaying it to the base stations directly, as they are in direct communication. In Sectors 1 and 3, the nodes are expected to send information to the base stations through clustering models. Hence, the selection of cluster heads occurs among the nodes in Sectors 2 and 3. After collecting the data from different individual nodes, the cluster heads are expected to aggregate it and, in turn, ensure that it is sent to the base stations. The figure below summarizes this arrangement and functionality.

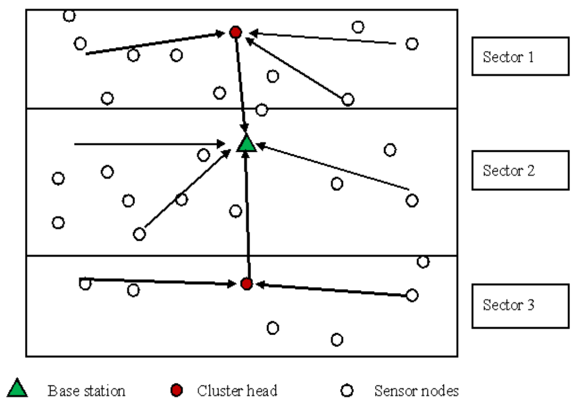

Fig. 2. Operation of ZEEL

D. Energy Efficient routing method when Base Station is outside of network

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For heterogeneous networks, the EEMCRPH and EEMCRP protocols are proposed. These frameworks utilize similar approaches regarding data transmission to the base stations. Particularly, they ensure that the information transmission to the base stations occurs directly. In the three sectors, data transmission by the nodes occurs through the clustering protocol. Also, it is in the three sectors that there is the selection of the cluster heads. Conversely, cluster heads engage in data collection from individual nodes before aggregating it and, in turn, sending it to the target base stations. The figure below demonstrates this arrangement and functionality.

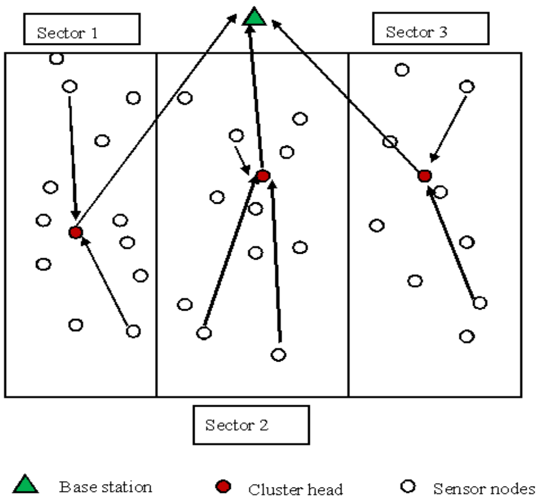

Fig. 3. Operation of EEMCRP and EEMCRPH

In this case, EEMCRPH utilizes the advanced nodes and normal nodes in the same fashion as the previous two algorithms. For the algorithm, it is also notable that its heterogeneity is similar to the SEP model. However, new arrangements are proposed relative to uneven cluster distributions in the respective epochs, deviating from previous models.

V. SIMULATION RESULTS AND ANALYSIS

To evaluate the performance of the proposed framework, simulation was conducted. Given a wireless network whose number of nodes was 100, and that the nodes were distributed randomly, the target field entailed 100m x 100m. The base station in the simulation was located at the sensing region's center. To determine the WSN network's lifetime, the number of rounds was recorded up to a point where one of the nodes ceased to function.

Table 1
Parameters used in simulations

Parameter	**Value**
Size of Network	100m X 100m
Bandwidth	1Mb/s
E_{elec} (Radio electronics energy)	50nJ/bit
E_{amp} (Radio amplifier energy)	100pJ/bit/m^2
E_{init} (Initial energy of node)	0.5J
Number of nodes	100
Data Aggregation(EDA)	0.5nJ/bit
ctrPacket Length of EDA	4000 bytes
Packet length	200 bytes

In this case, the probability of becoming a cluster head is represented by P for each round. Also, p is set at 0.05. To evaluate the performance of the algorithm, the amount of time in which the network is stable is considered, with the network lifetime reflecting the interval from the beginning of its operation up to a point where one node dies. Also, the measurement of the throughput is realized through the number of aggregated data packets that the cluster heads send to the base stations successfully, as well as the total energy that the network dissipates.
From the figure below, the algorithms' network lifetime is compared. Indeed, the proposed EERACBS model exhibits superior performance than previous algorithms because of its new form of division. It was also after 6234 rounds that the

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nodes died in the proposed system, outperforming the case of LEACH, in which nodes died after 1210 rounds.

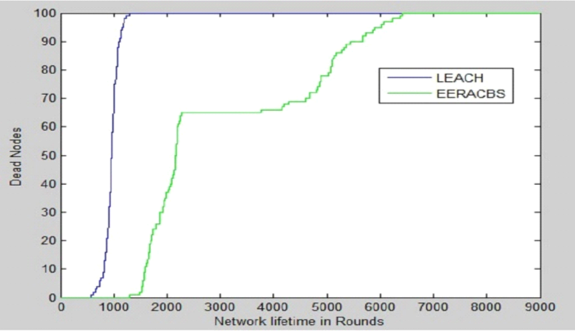

Fig. 4. Comparison of network lifetime between LEACH and EERACBS

In Figure 5, it is evident that relative to the base station, EERACBS sends more packets than other models with which it was compared. From the initial value of 2.5 x 105 data packets received from various cluster heads, the algorithm is seen to transmit 2.02 x 105 data packets in its whole lifetime. Here also, EERACBS has shown improvement in transferring packets to BS with the other algorithm.

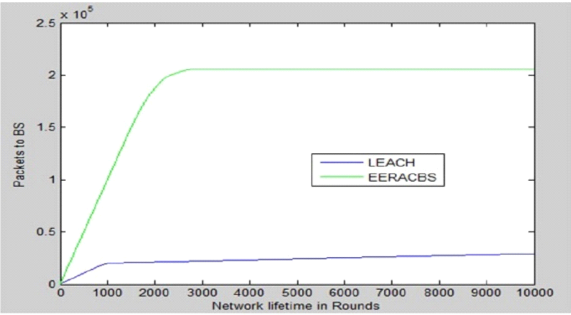

Fig. 5. Comparison of aggregated packets transferred between LEACH and EERACBS

The figure below compares the performance of the network lifetime for the three algorithms. The proposed algorithm is found to be very favorable against all other protocols. The EERACBSH has shown more than 10000 rounds while SEP and LEACH have only 1214 and 2202 rounds of network lifetime respectively.

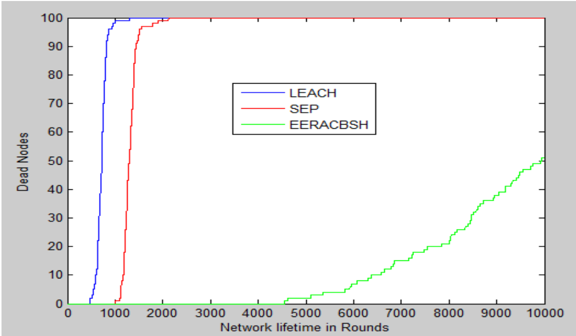

Fig. 6. Comparison of network lifetime between LEACH, SEP and EERACBSH

The proposed algorithm is also able to transfer 2.7 x 105 data packets compared to 1.2 x 104 data packets and 1.09 x 105 data packets of SEP and LEACH respectively.

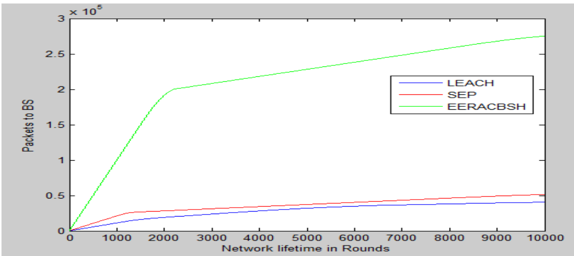

Fig. 7. Comparison of aggregated packets transferred between LEACH,SEP and EERACBSH

18265 CHs are formed during their entire network lifetime in total rounds for EERACBSH.

The network lifetime of ZEEL outdid LEACH as depicted in the graph in Figure 10. The proposed algorithm shown 3200 network lifetime when considered as homogeneous network.

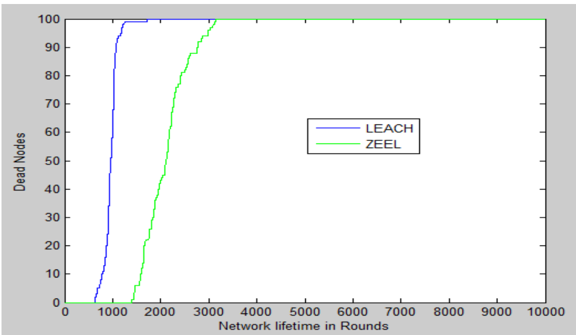

Fig. 8. Comparison of network lifetime between LEACH and ZEEL

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While the the throughput in sending more packets to BS by ZEEL able to send 2.2 x 105 more data packets when compared to the existing algorithm.

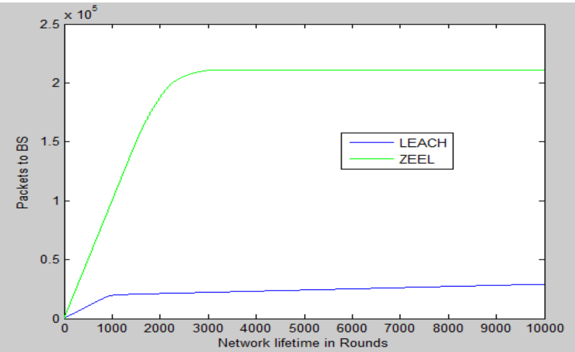

Fig. 9. Comparison of aggregated packets transferred between LEACH and ZEEL

EEMCRP algorithm shown better network lifetime of 3500 network lifetime as that of 1250 network lifetime of LEACH

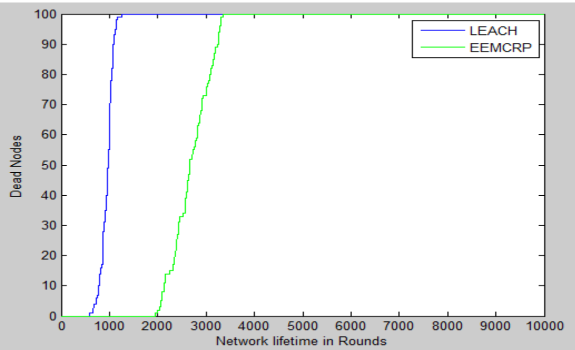

Fig. 10. Comparison of network lifetime between LEACH and EEMCRP

The total data packets aggregated to BS of EEMCRP is more compared to LEACH algorithm as depicted in the figure. It has sent 2.7 x 105 data packets compared to 0.7 x 104 data packets as of LEACH algorithm.

When compared to number of CHs formed during entire lifetime also, EEMCRP had shown more CHs formation than the LEACH algorithm as indicated in the figure. The number of CHs formed during entire lifetime is 5100 compared to 2455 as of the existing algorithm.

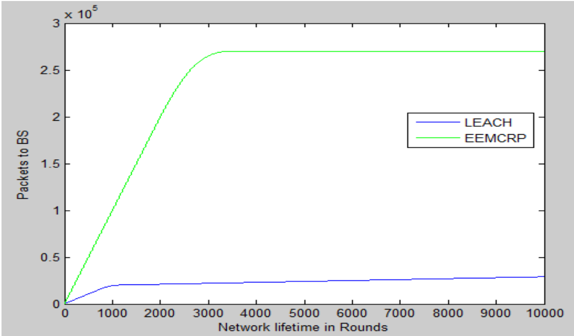

Fig. 11. Comparison of aggregated packets transferred between LEACH and EEMCRP

The network lifetime when compared with existing algorithms LEACH and SEP, the proposed algorithm for heterogeneous networks with BS far away from the network has shown better lifetime as shown in the figure. The EEMCRPH has shown more than 10000 network lifetime than the existing algorithms.

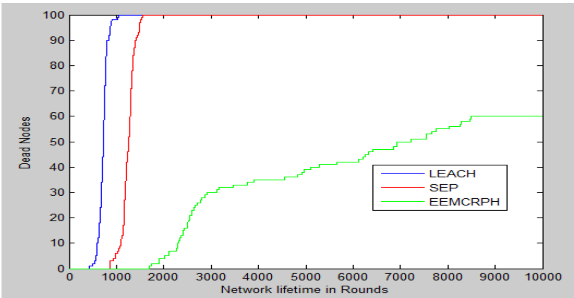

Fig. 12. Comparison of network lifetime between LEACH, SEP and EEMCRPH

The total data packets sent to BS when compared with existing algorithms, EEMCRPH has indulged in better approach. The proposed has also sent 2.9 x 105 data packets to BS during their lifetime.

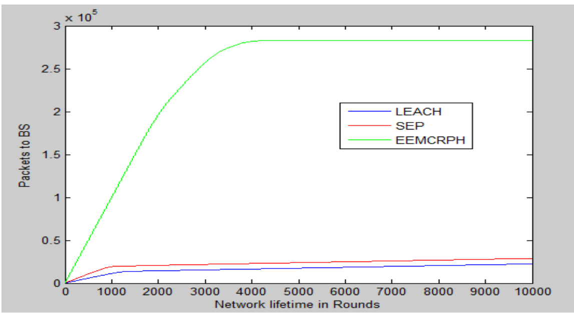

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Fig. 13. Comparison of aggregated packets transferred between LEACH and ZEEL

EEMCRP had shown more CHs formation than the existing algorithm. When compared to number of CHs formed during their total lifetime. The number of CHs formed during entire lifetime is 17100 compared more to those of the existing algorithms.

VI. CONCLUSION

EERACBS and EERACBSH are proposed for homogeneous and heterogeneous networks respectively with uniform division of clustering and necessary clusters are incorporated for nodes with Centered BS. The nodes near to the BS are utilized for direct transmission. They have shown better features and statistics taken from simulation when compared with previous algorithms. The other algorithm like ZEEL is proposed with different horizontal sector segmentation and also proved better compared to earlier algorithm. EEMCRP and EEMCRPH are also proposed with sector divisions prior to EERACBS and EERACBSH comparisons for BS far off from the network. The above two algorithms are proposed for Centered BS and other two algorithms for BS away from the network. These methods proposed in this paper would adopt better approaches for routing protocols than the previous algorithms existed in the literature so far.

Conflict of Interest: The author declares no conflict of interests.

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