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Original Article

Location based Energy Efficient Routing Protocol for Improving Network Lifetime in WSN

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Abstract *- Localization in sensor networks produces a major impact on improving the network lifetime of nodes. Cluster formation and Cluster head election are the key criteria for increasing the energy efficiency of the network. In existing schemes, the focus on cluster and localization with a multi-hop environment is not considered and balanced to attain a stable network. In this research, a Dynamic Energy Efficient Localization model is explored to reduce energy consumption through the geographical position of nodes. In this work, a cluster region is formed with server nodes, and Cluster Head (CH)is elected based on significant parameters, i.e. node energy, the delay between nodes and the distance between nodes. These parameters are maintained at the threshold level to choose a cluster head. Network topology is created with vertices to ease the deployment of the node with the most accuracy. Multiple paths are discovered to route the packets with the selection of reliable path and least route metric. Data transmission begins with efficient route establishment and localization of cluster members with the most accuracy and least localization error. Simulation results are taken and analysed using the network simulator tool, and network performance metrics, i.e. location accuracy, delay, packet delivery ratio, throughput, and packet least percentage, were taken and show the improvement in the proposed model.*

Keywords *- Energy model, Cluster routing, Network topology, Multipath discovery, Localization and data transmission*.

1. Introduction

Wireless sensor network (WSN) contains sensor nodes that consume less energy and limited battery. Based on environmental conditions, sensor nodes automatically sense the data and report it to a nearby node or CH. In some unpredicted scenarios, sensor nodes are used to monitor environmental situations. In difficult situations, sensors can be installed in specific areas to monitor the environment. Network topology and power consumption are important to improve the network throughput of complex WSN problems. The existing clustering methods are ineffective in terms of energy efficiency. The cluster technology controls the network topology for segmenting the node cluster. Effectively manage the network topology. WSN intelligent classification and energy-saving hierarchical unbalanced clustering, continuous recurrent neural network probabilistic neural network [1] and fuzzy neuro method [2].

In WSN, power consumption is the major challenge in cluster-oriented architecture. In order to improve the life of the network, it is essential to create an energy-saving cluster protocol. One of the most popular grouping methods is grouping sensor nodes to save energy. Each cluster zone contains nodes called members and cluster heads (CH). The sink node contains a packet integrated through channels to find specific information. If the clustering method is used, nodes can save a lot of energy, minimize network traffic and have a longer lifespan. Energy efficiency and limited mobility are the key factors of large scalable networks with cluster technology. Clustering is the best way to achieve an efficient and measurable sensor network. Better energy saving and greater resource allocation are the advantages of the cluster system. Longevity, clustering, and scalability are key dynamic cluster architecture options that start with feedback. These functions support dynamic clustering and help to achieve tracking goals. With the emergence of dynamic clustering technology, the development of static clustering algorithms shows more possibilities. An introduction to the dynamic clustering method can be found, but it may be expensive.

The concept of voronoi flow was analyzed in dynamic clusters, which have a higher degree of calculation and the problem of the selected CH technology. The node energy used for the selected channel is considered, and the distance from the channel to the receiving node and the unlimited cluster size are ignored. The sensor nodes are divided into the cluster region linked to the respective cluster, and each cluster contains CH and CM (cluster members). In some cases, data distribution is accomplished in the cluster head, and data is being shared by CM. If a base station is installed, it receives information about the cost of each channel. Research in the field of CH selection is still ongoing. They exist in the ability to ignore channel selection, identify unrelated sensor nodes, and low scalability of the cluster zone.

The dynamic energy-efficient localization model is introduced in this research work with some contributions. Network topology is derived to support the location of nodes with respect to CH. Nodes are communicated through multiple routes to avoid network overload and packet loss. Energy is derived from the whole network and saved for data transmissions.

2. Literature Review

The dynamic energy-efficient localization model is introduced in this research work with some contributions. Network topology is derived to support the location of nodes with respect to CH. Nodes are communicated through multiple routes to avoid network overload and packet loss. Energy is derived from the whole network and saved for data transmissions.

A meta-heuristic search algorithm is introduced in [3] to choose the optimal cluster head based on, i.e. energy, delay and distance. The results showed that the number of lively nodes and cluster head energy had greatly improved. The weighing model was proposed, and a cluster head election problem was identified to find stable routes and network lifetime improvement.

In [27], the concept of efficient energy routing is introduced through reliable relay nodes based on some metrics. The concept of Voronoi cells was adopted to choose reliable nodes among the group of nodes during the route maintenance phase. The cluster subsets are virtually formed through chosen relay nodes with two hop neighbor nodes. The hidden Markov prediction method was implemented to increase energy efficiency.

Energy-aware neuro fuzzy routing mechanism [5] was explored to improve IoT-based sensor networks' network lifetime. The cluster region was framed and connected with the Base station. The cluster network region consists of sensor nodes, cluster heads and Base stations. Routing information was updated in the routing table and forwarded to CH, which will directly communicate to BS.

The concept of a Cluster Head selection scheme [6] was adopted for the central network. The selection of optimal CH is the biggest issue and challenge. Due to the frequent selection of CH, the routing performance was affected, and nodes may be communicated in node selection rather than data transmission. Cluster formation and Data communication may be affected by the above-said issues.

Network topology and Protocol operation are defined under the category of routing protocols. Many routing models were adopted to provide robustness, good data transmission and high scalability. To enhance the network lifetime, some hierarchical routing protocols [26,28] have to be deployed. In some networks, significant developments have to be made in cluster networks. The network performance and energy conservation [4] are to be minimized by deploying the Hierarchical routing, and data communication is forwarded to Base Station.

In [8], authors suggested the Particle Swarm Optimization (PSO) method to adopt energy-based cluster regions through optimal selection of CHs. The discovering costs for cluster heads are minimized through this method. The PSO method was adopted in the place of the Base Station to identify the functions of the distance between cluster members, node degrees and hop count.

The concept of Energy efficient communication protocol [9] was adopted with the energy-efficient routing protocol. Here data collection and aggregation were done within a cluster for forwarding packets to Base Station (BS). Due to the random mobility mode, random CH deployment of CHs was useless. The CH selection and position of CH are determined based on a centralized approach.

In [10], the authors suggested Particle Swarm Optimization to select optimal cluster heads and reliable paths through nodes' distance and energy level. The fitness functions were estimated to improve the performance of the optimization method. The lifetime enhancement of CH was done with the protocol information transfer mechanism.

In [29], cluster and routing schemes were reviewed through the LEACH protocol for sensor networks. From these findings, energy-aware routing was adopted with the adaptive clustering method. Some basic metrics were taken, such as power management, Choosing CHs, Network lifetime and transmission through multi-hop routes. The advantages and disadvantages of the routing mechanism were also highlighted.

In [12], the concept of cluster chain routing to evaluate the CH selection based on remaining energy, packet transmission rate, the distance between intermediate nodes and the amount of energy required for packet transmission. In this routing, the node may be isolated due to unawareness of CH selection of neighbors. Meanwhile, a high delay may be produced.

In [13], the cluster is formed, and Cluster Head (CH) is chosen based on residual energy. The basic routing protocol LEACH was integrated with the proposed approach and considering parameters are initial energy, individual cluster members and the optimal number of Cluster Heads (CHs). These issues are carried out and solved in the classical LEACH algorithm[30].

In [11,14,16], authors illustrated the concept of energy supply and route selection procedure to consume energy through sensor nodes. The parameters are adjusted to increase the energy efficiency of sensor nodes.

In [15], an energy-balanced service quality scheme was developed to select cluster leaders. Network performance is improved by placing more sensor nodes in the cluster at once. The internal cluster is designed to distribute the load evenly. A cluster leader was selected, and a schedule was established to start transferring data on short parallel chains.

In [30], various heterogeneous protocols were adopted to improve the quality of service and network lifetime. It was observed that designing and implementing complex scenarios will be challenging for the decision-making process. The sensor nodes may generate random data and sometimes contain useful information.

The system performance was improved through the MAC algorithm. Various strategies were adopted to improve the system's performance. This method considers all network layers and consumes less network lifetime while estimating key computations [17].

A hybrid energy-efficient protocol [18] is implemented to gauge the space between the CH to the sink node. There were many security protocols adopted for identifying the attackers. Some specific keys are installed to reduce network energy consumption.

In [31], clustering protocol for energy-efficient routing uses ant colony optimization to select the best route to transmit data better. Improvements have been made in terms of balance performance and load balancing. Over time, the network has been modified to determine the importance of routing in the network. The network connection has been further improved to change the rotation of the cluster head and avoid using the bread search algorithm to collect data.

In [7, 20-25], authors focused on improving energy efficiency through balanced clustering, Genetic algorithm, and cluster head selection model. However, it was not focused on a location-based centric model for improving energy efficiency in the network.

The proposed work describes the overview of Wireless Sensor networks and the impact of cluster formation and localization model. In the second phase, a survey related to the multipath environment, localization and sensor node deployment was taken. In the third phase, a localization model based on node energy consumption is proposed to improve network lifetime. In the fourth phase, performance metrics and simulation results are discussed, and work is concluded in the last stage.

3. Materials and Methods

In this phase, the network topology is derived to support the localization approach to locate sensor nodes in the cluster region. The route cost and packet forwarding capability of routes decide the selection of reliable routes in the cluster region. A cluster region is formed based on the node's significant parameters. Cluster head election and reliable node selection play a major role in deploying the nodes in cluster sensor networks. The data transmission phase is achieved through reliable nodes, and the network lifetime is improved effectively.

3.1. Network Topology

In this phase, the topology of the cluster network is determined in the graph CH(N,V), where N is the set of cluster members and V is the set of edges where all nodes are connected together. The location of a cluster member is $cm \in CH$, which defines all cluster member coordinates belonging to Cluster Head. Cluster network topology is the dynamic one where any node can be chosen as the head that maintains the network connectivity and least path cost. The least cost path is estimated based on the number of data packets that reach the destination node without any loss. It is decided by calculating the energy level, distance and delay that occurred between cluster members. Cluster network improves network lifetime by maintaining limited mobility of cluster members with respect to CH.

3.2. Initial Phase

1. The cluster head initiates the route discovery process by adding the parameters, i.e. delay, energy and distance in Route Request (RREQ) packets.
2. Once the sensor nodes are joined as cluster members in the cluster region. If any cluster member receives RREQ packets from its nearby cluster member in its route, the maximum delay and bandwidth will be estimated to forward packets effectively.Cluster head identifies the cost of the route based on delay, energy and distance and announces it as the primary route. The primary route information will be forwarded to cluster members located towards the destination node.
3. High-cost energy paths will be discarded by the CH.
4. Packet forwarding capability is determined based on the number of paths that carry packets successfully to the end node. Each path must maintain threshold capability to route the packets.

Table 1. Simulator settings for DEELM

No. of sensor nodes	200 nodes
Routing protocol	LEACH
Simulation area	1000 x 1000 sq.m
Mobility model	Manhattan Model
Traffic	Variable Bit Rate
MAC	IEEE 802.15.4
Frequency	2.4 GHz
Packet rate	5 packets/sec

3.2.1. Reliable Path Selection through Cluster Head Selection Model

In this phase, cluster head and cluster members are chosen based on some parameters of the node-to-node distance, the energy of the node and delay. Here the chosen cluster head is located near the respective cluster. The distance between the sink node and the cluster head is kept at a minimum. The anchor node is placed nearby to the destination node and neighbor nodes. The role of the anchor node is to monitor the behavior of the destination node and forward it to the cluster head. During the data transmission process, energy dissipation between the nodes should be reduced by choosing appropriate cluster heads. Based on three significant constraints such as delay, energy and distance between the nodes, the selection of cluster head is obtained based on the following function

$$CH_F = \delta b_1 + (1-\delta) b_2 ;\ 0 < \delta < 1 \quad (1)$$

Where,

$$b_1 = \chi_1 \times b_j^d + \chi_2 \times b_j^E + \chi_3 \times b_j^D \quad (2)$$

$$b_2 = \frac{1}{m} \sum_{q=1}^{n} \left\| M_{sn}^q - m_c \right\| \quad (3)$$

In the equation χ_1, χ_2, χ_3 are the delay, energy and distance metrics. The addition of all these significant parameters should be unity based on the minimization function to determine the effective cluster head.

$$\chi_1 + \chi_2 + \chi_3 = 1 \quad (4)$$

This section derived the energy model based on the trilateration localization method. Since it is a basic model, it can be adopted in any kind of environment.

The appropriateness function of the energy parameter is given as,

$$b_j^E = \frac{b_{(1)}^E}{b_{(2)}^E} \quad (5)$$

Where

$$b_{(1)}^E = \sum_{p=1}^{C_{CM}^m} mE_r(p) \quad (6)$$

$$b_{(2)}^E = C_{cm}^m \times \underset{C_n^m}{\overset{p=1}{Max}} \sum_{p=1}^{C_{CM}^m} mE_r(p) \quad (7)$$

Where $b_{(1)}^E$, $b_{(2)}^E$ are the energy level determined from cluster members and cluster. In this equation, if the value b_1^E is greater than unity, the cumulative energy value becomes the highest energy metric value to determine the minimum cluster head count. Once the appropriateness function of energy parameter and cluster head selection is obtained, the cumulative energy metric will be calculated as follows,

$$mE_h(p) = \sum_{q=1}^{M} \left(1 - E\left(M_{sn}^q\right) \times E\left(N_{CM}^J\right)\right) ;\ 1 \le p \le C_{cm}^m \quad (8)$$

Where, $E\left(M_{sn}^q\right)$ and $E\left(N_{CM}^J\right)$ are the energy calculated based on sensor node energy and cluster energy. If more number of sensor nodes participate as cluster members, the cluster head will permit to initiate the data transmission. The energy of sensor nodes is improved by limiting unnecessary data transmission to the destination node. The appropriateness function of distance metric is measured as,

$$b_j^D = \frac{b_{(1)}^D}{b_{(2)}^D} \quad (9)$$

Where $b_{(1)}^D$, $b_{(2)}^D$ are the distance level metric determined between cluster members and cluster members to the cluster head.

4. Results and Discussion

The proposed work is simulated in this section using a network simulation tool (NS2.34). The language used for simulation is C++ and Tool Command Language (TCL). The simulation area in the network animator window used is 1000 x1000 meter square. The bit rate used for traffic in the simulation is the Variable bit rate (VBR). The settings of the DEELM simulation are illustrated in Table 1. The performance metrics are given as follows.

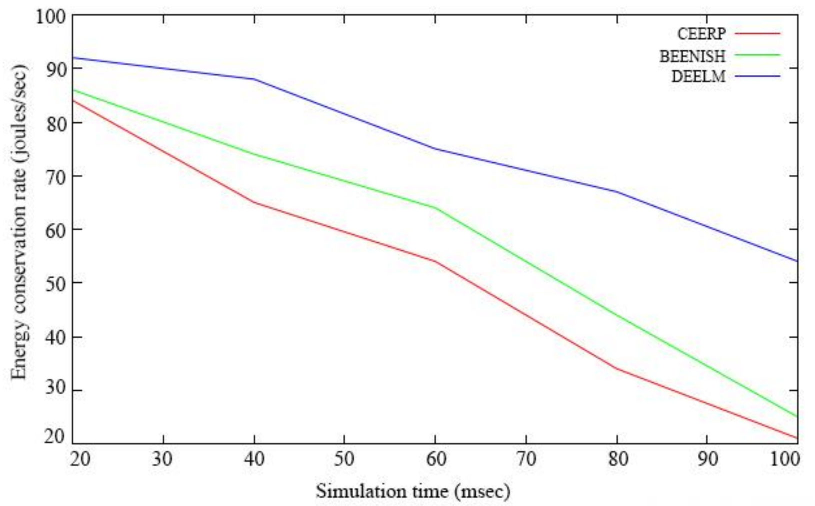

Fig. 1 Energy conservation rate vs simulation time

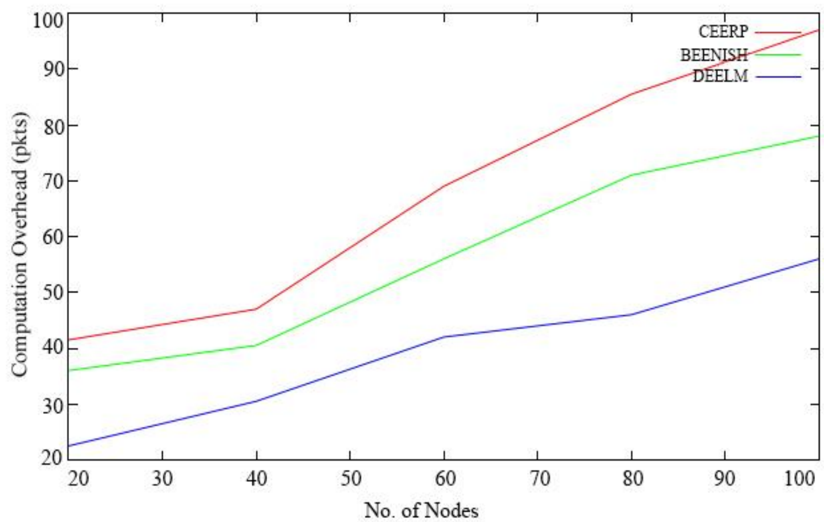

Fig. 2 Computation overhead vs no. of nodes

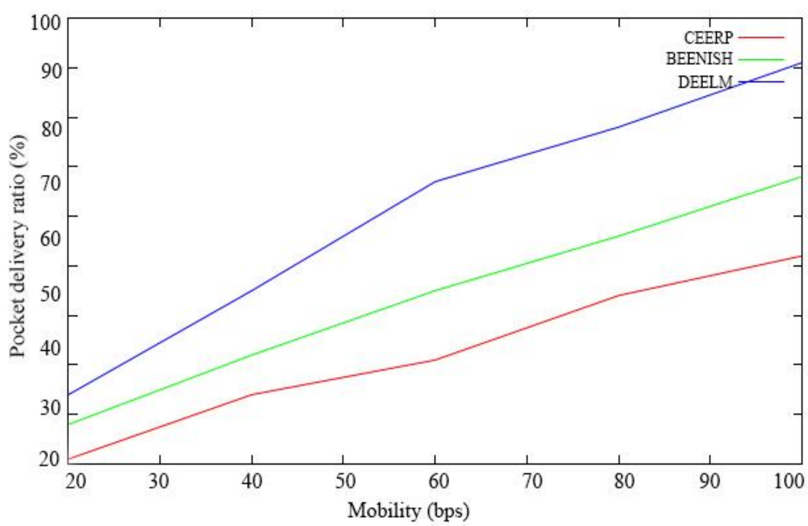

Fig. 3 Packet delivery ratio vs mobility

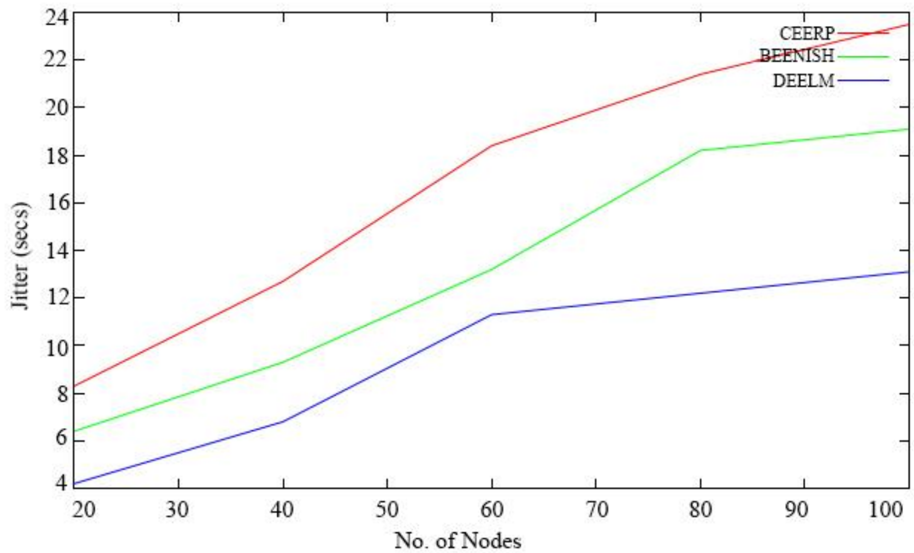

Fig. 4 Jitter vs no. of nodes

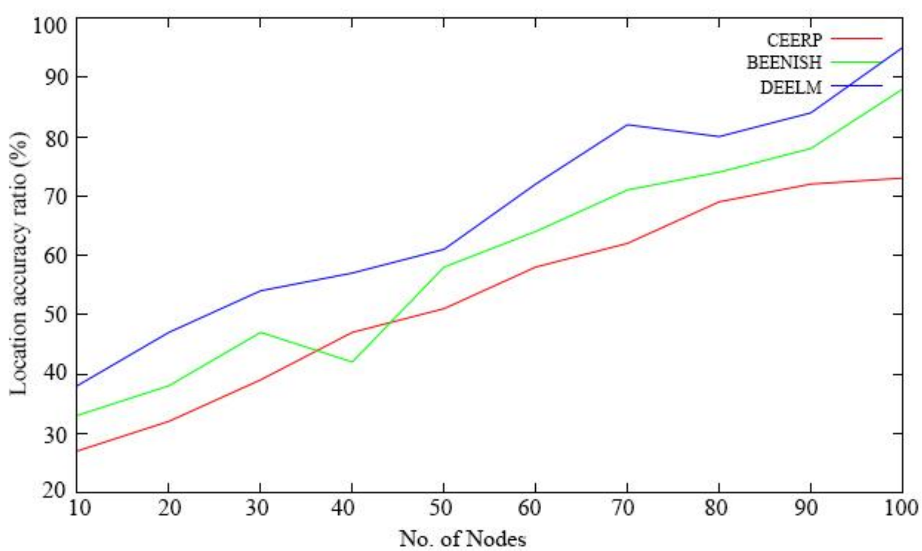

Fig. 5 Location accuracy ratio vs no. of nodes

Jitter: It is the piece of delay which occurs during packet movement from source to sink node.

Energy Conservation rate: It is the rate at which the number of nodes consumes energy for packet forwarding.

Packet delivery ratio: It is the ratio of packets delivered to the destination or sinks node to the packets sent from the source node.

Computation Overhead: It is the volume of excessive control packets travelling in the links.

Location accuracy ratio: It is the ratio of finding accurate nodes' locations to randomly deployed ones.

The Proposed work DEELM is simulated and compared with the existing schemes CEERP [18] and BEENISH [22], and the results are simulated, which is shown in Figure 1.

Figure 1 presents the performance analysis of the energy conservation rate of DEELM and existing schemes. It is found that DEELM achieves a low energy conservation rate due to deploying a residual energy model.

Figure 2 presents the overhead computation comparison of DEELM, CEERP and BEENISH. Based on the graphical results, it is clear that DEELM achieved low overhead due to network architecture integration.

Table 2. Comparison of schemes in terms of performance metrics

Metrics	DEELM	CEERP	BEENISH
Energy conservation rate (Joules/Sec)	92-54	87-27	82-22
Computation overhead (pkts)	9-14	11-19	13-23
Jitter (msec)	4.2-13.6	6.3-18.4	8.3-24.5
Location accuracy ratio (%)	38-96	32-88	28-72
Packet delivery ratio (%)	22-91	19-68	11-52

Figure 3 illustrates the packet delivery ratio analysis while varying the mobility in the x-axis. From the results, it is found that DEELM achieves a high packet delivery ratio with the help of network localization.

Figure 4 illustrates the DEELM in terms of jitter where in the x-axis, the number of nodes is varied up to 100. From the results, it is observed that DEELM achieves low jitter than existing schemes.

Figure 5 shows the analysis of the location accuracy ratio of DEELM compared with existing schemes. By adopting the localization model, DEELM produces more location accuracy than other schemes.

5. Conclusion

Attaining high energy efficiency is the biggest task in Wireless Sensor Networks, whereas sensor nodes are used to monitor environmental defects and surveillance applications. In this environment, maximizing the network lifetime is a challenging issue.

From the observation, the proposed model DEELM is introduced with hybrid network topology and dynamic cluster formation and a suitable CH selection scheme. Network topology supports the localization model to ensure high location accuracy. The cluster head is elected based on network performance metrics. Multipath routes are discovered from CH to the destination node by selecting reliable routes.

The localization phase is initialized to ensure maximum node accuracy. Data transmission is initialized to improve the packet delivery ratio. Based on the simulation results, DEELM achieves more packet delivery ratio, the least packet loss percentage, the least delay, more throughput, low jitter and overhead. In future, it is planned to propose to provide data integrity with the latest cryptography schemes.

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