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CLBEOR: Cluster Based Load Balancing Energy-Aware Optimized Routing Algorithm With Energetic Routing Optimization Technique In Wireless Sensor Network

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Abstract: The applications of Wireless Sensor Networks have got vital application domains in modern era especially in monitoring and tracking of events, and without human intervention. In WSN, sensor nodes are considered to have short life duration appropriate to continuous sensing and consequently the battery drains quickly. Under the heavy load energy utilization condition sensors in close proximity to Cluster Head expire quickly and initiate energy-hole problem. Thus, optimal usage of available energy is a key challenge in WSN assisted applications. To overcome these issues, this paper proposed a Cluster based Load balancing Energy-aware Optimized Routing Algorithm (CLBEOR) with Energetic Routing aware Kernel Fuzzy Latency Particle Swarm Optimization Algorithm (ER-KFPSO) is performed with four major steps; Clustering, CH selection, Energy Utilization and optimization-based route identification for data transmission. The proposed load balancing optimization ($Path_{adjustment}$) is used for optimal route selection from cluster head to the sink node. The performance of CLBEOR is compared with the existing optimization-based routing algorithms. It shows an improvement in terms of packet delivery ratio and packet delay ratio as compared to other existing PNLP and KFPSO algorithms.

Keywords: Quality of Service, Wireless Sensor Networks, Energetic Routing, Particle Swarm optimization, Cluster Heads, Load Balancing.

1. INTRODUCTION

Energy efficiency and increasing network longevity are the main focus of research in the domain of Wireless Sensor Network (WSN) for the last few years. In order to achieve high quality and better coverage of a certain region, a sensor network consisting of hundreds or thousands of sensor nodes is randomly deployed within the affected area or very close to it [1]. This results in more than one node sensing the same event. All these nodes try to send the redundant data to the sink node using multiple paths leading to a huge amount of energy drainage.

In general, a node in WSN utilize more energy while data transmission in comparison to processing and sensing [2]. The energy utilization increases manifold when a node start transmitting data to a base station (BS) situated at longer distance. The BS is a powerful machine that contains enough storage, processing abilities and also it doesn't have any power constrains [3]. Some approaches have introduced multi-hoping communication to reduce distance covered [4, 5]. To enable multi-hoping, several routing protocols are designed that operates on different strategies like data-centric, geographic location-based, clustering and hierarchy-based [6]. The data-centric protocols initiate data transmission between nodes and BS through relay nodes [7]. These types of protocols reduce data redundancy and minimize the amount of data packets transmission. At the same time, these protocols reduce scalability of the network.

In figure 1 represents cluster-based WSNs, the sensor nodes are organized into distinct clusters. Each cluster is under the management of a master node called CH. In this organization, the nodes of a cluster send their data directly to the corresponding CH. This latter collects data from its cluster member nodes to send them directly or possibly through other CHs to the sink. Clustering a WSN has the following advantages. (1) It ensures data aggregation at CH level which can reduce energy consumption by discarding redundant data. (2) Routing can be managed easily since only special nodes such as CHs need to maintain the local route setup of other CHs and thus need small routing information. Furthermore, this will improve significantly the network scalability. (3) It also conserves the communication bandwidth because sensor nodes communicate only with their respective CH and thus avoiding the exchange of redundant messages between them.

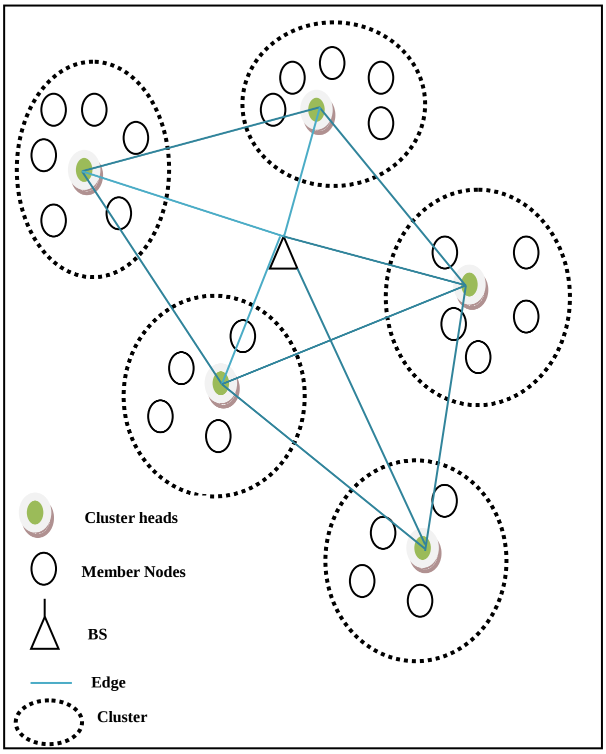

Fig. 1: Graphical representation of a cluster heads network

The multi-objective of the proposed work is to optimize energy balancing among sensor nodes, route formation between CH (Cluster Head) and BS (Base Station). The objectives like proximity, communication cost, residual energy and coverage are considered for node clustering and CH selection. The proposed work is mainly to give an extension of the ER-

KFPSO: Energetic Routing Technique Based Kernel Fuzzy Latency Particle Swarm Optimization Algorithm [16] which is based on clustering and minimizing energy by making use of Cluster based Load balancing Energy-aware Optimized Routing Algorithm (CLBEOR) for effectively improving the life time of the WSN.

The remaining content of the paper are organized as follows: Section 2 deals with the existing methods given as literature surveys, Section 3 describes the proposed method and section 4 discusses the experimental results followed by conclusion.

2. LITERATURE REVIEW

(*Kadi, M., Alkhayat, I.,* **2015 [8]**) introduced a Location-based routing protocols use position information for making packet forwarding decisions, assuming perfect location information. Unlike topological routing algorithms, they do not need to exchange and maintain routing information. They work nearly stateless. However, in practice there could be significant errors in obtaining location estimates. The authors discussed the impact of location errors on power consumption of these protocols will be analyzed via developing a mathematical model represents the location errors that may occur in real deployment. Then a simulation of the power consumption of two location-based routing protocols, Geographic Random Forwarding (GeRaf) and Minimum Energy Consumption Forwarding (MECF), is carried out to evaluate the mathematical model.

(*Arioua, et.al.,***, 2016 [9]**) discussed a key challenges in wireless sensor networks is the efficient usage of restricted energy resources in battery operated sensor nodes. Clustering remains the most effective routing approach used in WSN. Low Adaptive Clustering Hierarchy (LEACH) protocol is an efficient routing approach which has been widely adopted and enhanced to improve the lifespan of deployed sensor networks. However, latterly, clustering algorithms have shown their limitation in extending the network lifespan. The authors proposed a new clustering approach based on a combination of LEACH and MTE protocols. The adoption of multi-hop communication instead of direct communication in cluster filed has optimized the communication in the network.

(*Duching, Rajesh, Sanjib and panda,* **2013 [10]**) Investigated on the real time execution of the energy aware cluster centric protocol for the WSNs. The proposed configuration of the apt clusters are of major impact for the energy sustainability and makes use of the sensor nodes inside each cluster of the WSNs. This invokes the energy conservation in the sensor nodes which consequently increases the life time of the network. Fuzzy C-Means clustering procedure was used for this purpose.

(*Zhou, et.al.,* **2017 [11]**) presented a new method to prolong the network lifetime based on the improved particle swarm optimization algorithm, which is an optimization method designed to select target nodes. The protocol takes into account both energy efficiency and transmission distance, and relay nodes are used to alleviate the excessive power consumption of the cluster heads. The proposed protocol results in better distributed sensors and a well-balanced clustering system enhancing the network's lifetime. They compared the proposed protocol with comparative protocols by varying a number of parameters, e.g., the number of nodes, the network area size, and the position of the base station.

(*Elshrkawey,et.al.*, **2018 [12]**) illustrated an enhancement approach to reduce the energy consumption and extend the network lifetime. It has been accomplished by augmenting the energy balancing in clusters among all sensor nodes to minimize the energy dissipation during network communications. The improved method is based on a cluster head selection method. In addition, an enhanced schedule of the TDMA has been implemented. Finally, the development approach indicates the progress in terms of network lifetime, Number of cluster head, energy consumption and number of packets transferred to BS compared to LEACH and other related protocols.

(*Mostafaei,*, **2019 [13]**) discussed a Quality of service (QoS) routing is one of the critical challenges in wireless sensor networks (WSNs), especially for surveillance systems. Multihop data transmission of WSNs, due to the high packet loss and energy-efficiency, requires reliable links for end-to-end data delivery. Current multipath routing works can provision QoS requirements like end-to-end reliability and delay, but suffer from a significant energy cost. To improve the efficiency of the network with multiconstraints QoS parameters, in this paper we model the problem as a multiconstrained optimal path problem and propose a distributed learning automaton (DLA) based algorithm to preserve it. Their approach leverages the advantage of DLA to find the smallest number of nodes to preserve the desired QoS requirements. It takes several QoS routing constraints like end-to-end reliability and delay into account in path selection.

(*N. Deepa and D.Devi*, **2019 [14]**) proved that the WSN consists of many independent devices that are spatially scattered and uses sensors together in monitoring the environmental variables such as the noise, pressure and temperature and also its motion and pollutants. The WSN includes an enormous amount of sensor nodes. These nodes are battery powered, power competence of the sensors is furthermore crucial. Appropriate to this the network routing procedure is executed based on two conditions namely sleep and active state. In various critical situation low energy nodes go to active state and execute communication procedures. Various sensor nodes rapidly lose energy causing message collapse. This amplifies energy utilization, network overhead, and end to end delay. Therefore they proposed Energetic routing Technique (ERT) is used to attain the energy efficient communication in wireless surroundings. This ERT efficiently monitors the low energy nodes and presented the elevated energy neighbor node list for additional packet promoting in sensor network and Constructing the Latency wise promote node selection algorithm is applied to eliminate maximum delay node, also choose lesser delay node for packet forwarding. Consequently it reduces the energy consumption, network overhead, and end to end delay.

(*N. Deepa and D.Devi*, **2020**, **[16]**) discussed a various techniques were proposed for the energetic routing in order to make a significant progress in the stability of the energy as it is a vital parameter of a WSN in times of data transmission for communication. These techniques are used for the life time enhancement of the sensor networks. Load balancing methods along with energetic routing are made used at the time of clustering. The authors proposed an Energetic Routing which is based on the Kernel Fuzzy Latency PSO (ER-KFPSO) for supporting the energy consumption in Wireless Sensor Networks for improvisation in the life time of the network. The proposed method gives assistance in shaping the clusters by making use of the Energy Fitness value along with assignment of CHs. The proposed technique achieves better results on experiments when compared with the other existing methods that uses Particle Swarm optimization based nodes and life time prediction method through linkage (PNLP).

3. PROPOSED METHODOLOGY

The proposed method of Cluster based Load balancing Energy-aware Optimized Routing Algorithm (CLBEOR) is performed with four major steps; Clustering, CH selection, Energy Utilization and optimization-based route identification for data transmission. It focuses on the problem of traffic overloading near to the sink. It has been elaborated in four steps: network setup, energy model, node clustering, and route identification. The network setup phase explains the sensor network creation and deployment. The energy model analyses the energy consumption while transmitting data over the nodes. The node clustering and CH selection explains grouping the nodes and creating clusters in the network. In the route identification phase, the optimal path for transmitting the data will be identified by using the KFPSO algorithm. The figure 2 describes the proposed method flow process.

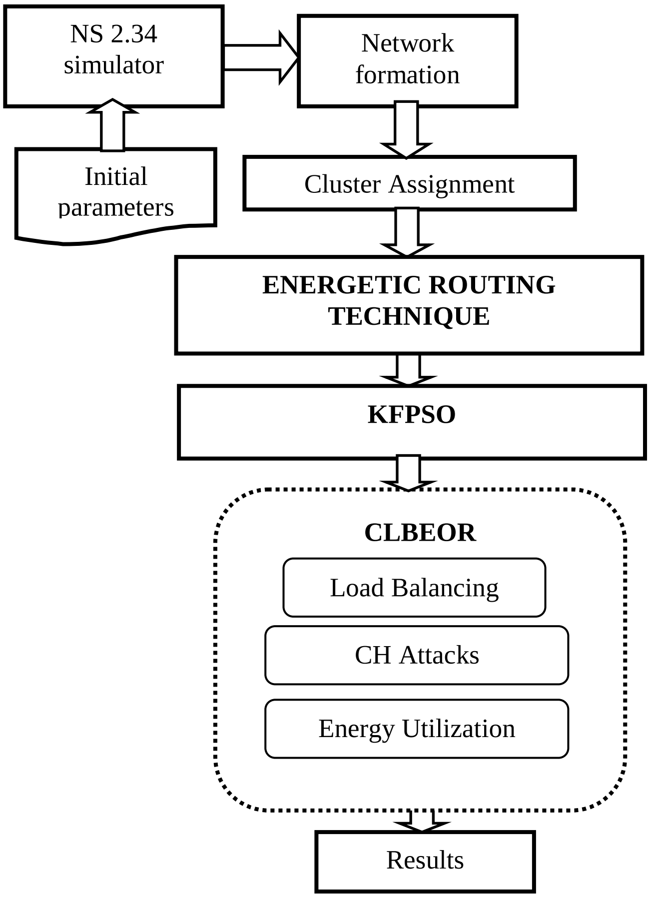

Fig. 2: Proposed Flow Diagram

a. Network Formation

Network model contains of M number of nodes deployed randomly within network simulation area. All the nodes ($M(k)$) are dynamic in terms of their creation, location and lifeless. Apart from all the general nodes, the cluster network has two well-configured nodes called as the base station (Bst) and Cluster Head (CH). The network formation is evaluated in graph model was already we presented (*N. Deepa and D. Devi Aruna*, 2019). The assumptions for the proposed network model are as follows:

- All sensor nodes are equipped with a non-rechargeable power source.
- Sensor nodes can't alter their location once they get deployed.
- The communication and processing abilities of all the sensors are the same.
- The initial energy of all the sensor nodes is equal.
- Transmission links among sensor nodes can diffuse data in any direction (bi-direction).

b. CLUSTER ASSIGNMENT AND ENERGETIC ROUTING

Cluster Assignment was already we presented (*N. Deepa and D. Devi Aruna*, 2019) considers the collection of Cluster Heads (CH) in a wireless sensor network of each node weights in this network are within distance of a CH, for a known weight fitness value.

The energetic routing technique process is used to discover the uses connected to smart node, where real time data packet observation is essential was already presented by (*N. Deepa and D. Devi Aruna*, 2019). In this model, the system will described a network with the following assumptions:

- The route or direction for communication using node energy Level Based Routing scheme follows ranking based nearest neighbouring node.
- The direction begins from origin node to the target node. The adjacent node to the target node in the related energy level is particular as the active node from which message is observed.
- Respectively, the procedure is frequent from the nearest neighbour node choose turn over the origin node to make a decision the entire route.

C. KERNEL FUZZY LATENCY PARTICLE SWARM OPTIMIZATION ALGORITHM (KFPSO)

The KFPSO was already we presented (*N. Deepa and D. Devi Aruna*, 2019) considers the shortest path routing method varies from normal PSO in only single respect: in each neighborhood, instead of only the finest particle in the neighborhood being permitted to weight its neighbors, a number of particles in every neighborhood can be permitted to weight others to a degree that depends on their degree of connectivity, where charisma is a fuzzy variable.

D. **CLUSTER BASED LOAD BALANCING ENERGY-AWARE OPTIMIZED ROUTING ALGORITHM (CLBEOR)**

The proposed CLEBOR process of data communication will be initiated once the best path is identified using KFPSO algorithm. During the transmission, it utilizes energy for transmission of data packets to the BS. It may cause death of CH or reduction in its energy. So, the algorithm, in each iteration, periodically monitors the path before initiating the data transmission. If any node having heavy load or insufficient capability to transmit the data, it will be removed from the path and alternate path is selected. The path adjustment will be carried out by Equation 1.

$$Path_{adjustment} = New\_P_{best} \text{ if } E_{Res}(CH_i) < \min\_thres \quad \text{eqn. (1)}$$

Where,

$$P_{best} = CH_i^{best} - \alpha \times \left(\frac{CH_i^{best} + BS_{position}}{2}\right) + CH_{old} \quad \text{eqn. (2)}$$

The above equation 2 the position of newly found CH is represented as CH_i^{best}, the position of CHs already identified as best and initial CH is represented as CH_{old}, α is represented by current path location.

From Eq. (2), the new best path will be identified from the available paths if the energy of any CH is less than the minimum threshold and it is described as $E_{Res}(CH_i) <$ min threshold. Where, min threshold = $E_{need}(CH_i, CH_j)$. The energy needed for transmitting data from the location of CH to next CH in the path is represented as $E_{need}(CH_i, CH_j)$.

The residual energy of node is estimated by,

$$E_{Res} = E_{Tot} - (E_{Collection} + E_{Trans} + E_{Recv} + E_{Agg}) \quad \text{eqn. (3)}$$

The total energy of an each sensor node is described as E_{Tot}, the energy utilized during the data collection is described as $E_{Collection}$, the energy utilized for transmitting data is described as E_{Trans}, the energy utilized for receiving the data is described as E_{Recv}, and the energy utilized for aggregating the data is described as E_{Agg}.

ALGORITHM 1: CLEBOR
Input: Amount of promising paths for routing to Base Station (BS)
Output: *Optimal routing path to BS*
Process
Step 1: Initialize Sensor nodes position, CH position and BS position
Step 2: Compute the fitness of CHs become a router forwarder
Step 3: while (true)
    For 1 to number of CH
     Calculate Energy of CH
      If energy is max
       Select CH node for data forwarding
      Else
       Discard CH node
      End if
      If CH is low or malicious
       Execute the alternate path selection process. Update the best path using eqn. (1)
      End if

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End while
Return best optimal path

4. PERFORMANCE EVALUATION

This performance evaluation illustrates the various parameters and the experimental conditions for the proposed method. The experimental environment taken is of a 500* 500 dimensioned field. The entire sensor are constantly isolated in the field and it is assumed that the Base station is located much inside the sensor area. Minimum system configuration is used and the settings on the parameter are describes as in table1. Ns2 simulator is used as the tool for performing the experiments.

TABLE 1: SIMULATION PARAMETERS

PARAMETERS	SYMBOL	VALUE
Number of Nodes	N	50~100
Network Region	Row $\times$ Column	500 $\times$ 500
Energy	E_{node}	100Joules
Initial Weight	W_i	0.42
Clsuters	CH	Differs

Average packet delivery ratio: It is the fraction, amount of packets conventional successfully and the total quantity of packets broadcasted. The proposed CLEBOR algorithm executes improved PDR ratio evaluated with existing PSO-based node and link lifetime prediction algorithm (PNLP) method [15] and KFPSO [14].

Table 1: Comparison of Packet Delivery Ratio with Existing PNLP, KFPSO with proposed CLEBOR

Number of Nodes	50	100	150	200
PNLP	96.25	91.5	88.23	85.99
KFPSO	97.55	92.4	86.58	84.55
CLEBOR	**98.85**	**94.22**	**89.63**	**86.38**

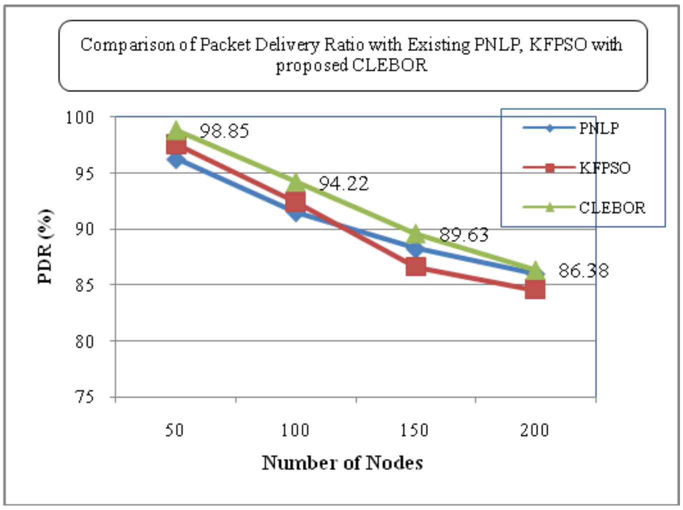

Fig. 3: packet delivery ratio

The evaluation of packet delay ratio is provided in the figure 4. In this figure, the performance of the CLEBOR is represented given in red line and the line in green denotes the performance of the existing PNLP [15] and KFPSO [14]. It is evident that the count of packet transmission has decreased. In the graph, Y axis denotes the delay ratio and the X axis denoted the Number of nodes in the experiment.

Table 2: Comparison of Packet delay ratio with Existing PNLP, KFPSO with proposed CLEBOR

Number of Nodes	**50**	**100**	**150**	**200**
PNLP	18	17	15	14
KFPSO	16	15	13.5	12.5
CLEBOR	**15.1**	**13.5**	**11.88**	**11.44**

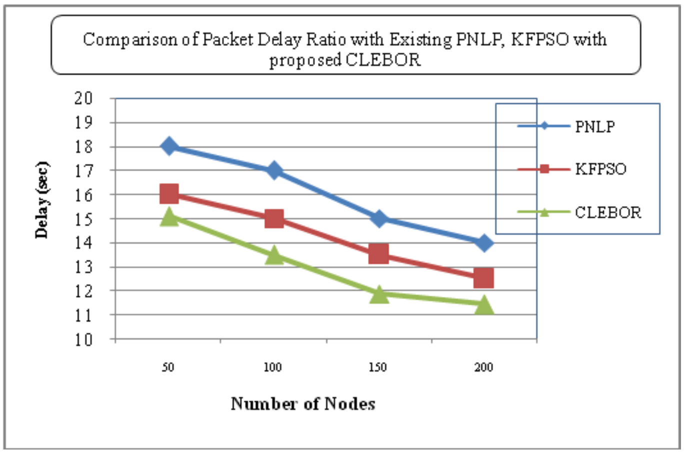

Fig. 4: Packet Delay ratio.

5. CONCLUSION

In the paper, proposed a Cluster based Load balancing Energy-aware Optimized Routing Algorithm (CLBEOR) with Energetic Routing aware Kernel Fuzzy Latency Particle Swarm Optimization Algorithm (ER-KFPSO) is proposed to support the energy consumption in WSN. The CLBEOR algorithm uses energy-efficient cluster head selection method based on multiple objectives like proximity, cost, residual energy, and coverage. The proposed load balancing optimization ($Path_{adjustment}$) is used for optimal route selection from cluster head to the sink node. The performance of CLBEOR is compared with the existing optimization-based routing algorithms. It shows an improvement in terms of packet delivery ratio and packet delay ratio as compared to other existing PNLP and KFPSO algorithms.

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