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ENERGY-EFFICIENT CROSS LAYER OPTIMIZED CLUSTERING ROUTING (EECLOCR) PROTOCOL AND CHAOTIC PUFFERFISH OPTIMIZATION ALGORITHM (CPOA) FOR WIRELESS SENSOR NETWORK (WSN)

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ABSTRACT: Wireless Sensor Network (WSN) are powered by batteries that have a limited capacity, the network's quality could decline at any timesince the majority of sensor nodes. It becomes quite challenging to decrease sensor node energy consumption and increase network lifetime. Every sensor node can use the limited energy more sensibly by creating an efficient clustering routing protocol. The four main operations that make up this system are Cluster Head Election (CHE), cluster creation, data fusion, and data transfer. Routing protocols, CHE nodes are crucial for effective communication in WSN. In this paper, Energy-Efficient Cross Layer Optimized Clustering Routing (EECLOCR) protocol is presented to organize the Sensor Node (SN) into clusters. Firstly, a novel K-medoids is first introduced for cluster formation. Secondly, the Chaotic Pufferfish Optimization Algorithm (CPOA) determines the number of CH and the optimal CH to choose, and sensor nodes are paired with the nearest CH. In each iteration, the CPOA algorithm selects a group of CH to construct various cluster networks in an attempt to identify the best possible network configuration. Use the intra-cluster distance, total distance, energy consumption, and residual energy ratio is introduced to optimize the selection of CH. It is capable of minimizing transmission distance and optimizing energy efficiency. Thirdly, network overhead is dynamically minimized by using the EECLOCR protocol to find the quickest route. Proposed method produced better results when evaluating the Packet Delivery Ratio (PDR), Packet Loss Ratio (PLR), Network lifespan, Energy Consumption, and throughput than other methods.

INDEX TERMS: Wireless Sensor Network (WSN), Cluster Head Election (CHE), Chaotic Pufferfish Optimization Algorithm (CPOA), Energy-Efficient Cross Layer Optimized Clustering Routing (EECLOCR) and

1. INTRODUCTION

Small, reasonably priced sensor nodes make up Wireless Sensor Network (WSN) [1]. Larger sensor nodes have the capacity to use more resources, and multimedia data is usually more comprehensive. This problem has been studied and attempted to be resolved by certain researchers [2]. Sending and receiving packets use most of the energy, so saving energy is major important in WSN to live longer. Batteries are widely used by WSN sensor nodes. The complexity of battery charging stems from the network of devices, making battery capacity the most valuable resource for WSN. Energy conservation consequently becomes a crucial concern in WSN. It is necessary to create a new optimization method in order to improve network longevity and energy efficiency. WSN, clustering divides the network into several clusters and designates a single node as the Cluster Head (CH) for each cluster [3]. CH lowers the Base Station (BS) overhead by aggregating the data received from each node and delivering it to the BS [4].

Forming and stabilizing are the two stages of each round that the clustering algorithm goes through. Different groups, or clusters, of nodes are formed. Every group has a CH assigned to it. After gathering information from sensor nodes, the CH transmits the detected data to the recipient. For clustering approaches to continue conserving energy, CH is election is major important during routing [5,6].To lessen the amount of transmission data during clustering, CH compresses the data it receives from each cluster and sends an aggregated packet to the BS. Along with handling general requests, CH is also in charge of gathering sensed data from other sensor nodes in the same cluster and sending it to the sink.

For this reason, compared to other nodes, the CH uses more energy. The CH in a cluster alternates between sensor nodes to equilibrium the energy utilization and lifetime maximization. As a result, this network longevity will be impacted by the CH selection process. Different lifespan definitions will be followed by different application scenario contexts. The data communication paths to the sink will therefore have an impact on the amount of energy used. The hierarchical architecture is often used in WSN because of it offers greater flexibility for routing issues. The alternate takeover of the CH would balance the nodes energy consumption to extend the network's lifespan, and the optimal CH selection may increase the energy efficiency of data transmission to the BS.

Energy-Efficient Cross Layer Optimized Clustering Routing (EECLOCR) is proposed for energy-efficient based WSN. Targeting the particular WSN issue wherein some nodes are rendered inoperable due to energy harvesting, the suggested OHCR protocol combines the distributed CH scheme using Chaotic Pufferfish Optimization Algorithm (CPOA) with the clustering method. It has less impact on the quantity or topology of clusters when using the node clustering method, which may create suitable node clusters based on the original node distribution. WSN nodes data fusion mode and appropriate data transmission have been introduced to CPOA, which ensures energy efficiency. Proposed method produced better results when evaluating the PDR, PLR, Network lifespan, Energy Consumption, and throughput than other methods.

2. LITERATURE REVIEW

Daneshvar et al. [7] introduced bynovel clustering approach, Cluster Head Selection (CHS), utilizing the Grey Wolf Optimizer (GWO). The predictable energy consumption and residual energy is considered as major important metric to choose CH. The suggested technique saved energy by using the same clustering in several rounds in a row to improve energy efficiency. CH are distant from the BS, a dual-hop routing method was created to ensure the least amount of energy consumption possible while still allowing single-hop communication for the remaining nodes. An alternative way to visualize network lifetime is as the number of rounds at which the First Node Die (FND), Half Node Die (HND), and Last Node Die (LND). When compared to many previous similar protocols, performance was assessed in a variety of circumstances and showed an improvement in network lifetime.

Han et al. [8] proposed by Clustering Protocol based Meta-heuristic Approach (CPMA). CPMA is divided into two components and prioritizes network lifetime. In the first section, online CHS and network communication coordination are the main topics. Harmony Search (HS) is presented as a way to lower overall energy dissipation and promote even energy distribution across the network. The Artificial Bee Colony (ABC) algorithm, the second component of the CPMA, is presented for the offline optimization of critical parameters. CPMA is more flexible and performs better under varying network lifetimes than FND, HND, and LND, proving its efficiency and applicability for a variety of WSN.

Ali et al. [9] created a novel algorithm called ARSH-FATI-based Cluster Head Selection (ARSH-FATI-CHS) and combined it with a heuristic called Novel Ranked-based Clustering (NRC) to lower the sensor nodes' communication energy consumption and increase network's Life Time (LT). This method can dynamically alternates between exploring and exploiting the search process during run-time to attain a higher trade-off between performance and efficiency. The ARSH-FATI-CHS approach was found to increase network lifetime by around 25.00% when compared to Particle Swarm Optimization (PSO).

Rodriguez et al. [10] proposed an Energy-Efficient Clustering Routing Protocol (EECRP) for WSN based on the Yellow Saddle Goatfish Algorithm (YSGA). By using less energy, the protocol aims to increase the network lifetime. In its cluster structure, the network takes into account a BS and a number of cluster heads (CH). YSGA algorithm determines the no. of CH and the best CH to choose, and sensor nodes are paired with the closest CH. It is also assured that the CH is distributed optimally to shorten transmission distances. Results show that EECRP reduces energy consumption, enhances network LT, and extends stability period than other methods.

Priyanka et al. [11] constructed dynamic CHS in each sub-sector using the Whale Optimization Algorithm (WOA). Remaining energy and network lifetime were used to assess the effectiveness of the suggested method. Energy reduction is possible in the round WSN by sectorization in the proposed model. The suggested method effectiveness was contrasted with protocols for Low Energy Adaptive Clustering Hierarchy (LEACH) and PSO. It was shown that the network LT was improved when the starting energy rise appropriate to an improvement in residual energy ratio.

Kalburgi and Manimozhi[12] created an efficient CH selection mechanism through the use of Taylor-Spotted Hyena Optimization (Taylor-SHO), which combines the Spotted Hyena Optimization (SHO) with the Taylor series based on delay, energy, and distance. Then, the modified k-Vertex Disjoint Path Routing (mod-kVDPR) algorithm was used to routing. It was created by altering kVDPR according to criteria like throughput and network reliability. Lastly, route maintenance was enlisted to track packet delivery and notify any broken links. The suggested method effectiveness was examined on a simulated network including 50 and 100 nodes. Proposed method was compared with other methods such as Herding Optimization-Greedy, Tabu Particle Swarm Optimization (TPSO), Grey Wolf Optimizer (GWO), and Distributed Energy Efficient Heterogeneous Clustering (DEEUC) with energy consumption, throughput and delay.

Ambareesh et al. [13] adopted to transmit aggregated data to the BS choose an ensemble clustering technique and used it to identify the best routing via CH to BS. This approach updates the position of the Hybrid Jarratt Butterfly Optimization (HJBO) algorithm by using the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), which in turn determines the ideal solution (i.e., optimal routing). FTOPSIS-HJBO, or fuzzy TOPSIS-HJBO, approach was assessed using a range of performance metrics. The proposed method achieved a greater throughput and a higher PDR.

Samiayya et al. [14] introduced a Hybrid Snake Whale Optimization (HSWO) to manage the network for broadcasting data to the destination by choosing the best CH from the cluster group. It consists three major phases like initiation, route maintenance, and CHS. The network, distance, and energy models are developed for the WSN model during the initialization. Route maintenance, an effective path is selected to broadcast the sensed data to the destination without experiencing any disruptions in the link. The worst CH is removed from the clusters using the HSWO method, which takes into account factors including distance, energy, and latency. This allows for the selection of the best CH. The HSWO algorithm is validated using a variety of performance metrics like network LT, energy and delay.

Cherappa et al. [15] described involves clustering sensor node (SN) utilizing K-medoids and the Adaptive Sailfish Optimization (ASFO). Select best CH by minimizing latency between nodes, reducing distance, and stabilizing energy. The shortest path is found by introducing an energy-efficient cross-layer-based expedient routing protocol (E-CERP), which dynamically minimizes network overhead. The findings of the suggested method were better than in terms of PDR, PLR, delay, throughput, energy consumption; network LT, error estimation than previous approaches.

Elashry et al. [16] presented the Chaotic Reptile Search technique (CRSA), hybrid Meta-Heuristic (MH) optimization technique for WSN energy conservation. RSA algorithm is fused with a chaotic map known as CRSA. RSA experienced local minimum trapping. The suggested approach increased diversity and avoided being trapped in local minima by utilizing the chaotic maps. Using the sensing field in a WSN, CRSA was utilized to choose the best set of CHs from among the other sensing nodes. Metrics like total energy consumption, no. of running nodes, packet receipt by the BS, and network LT (HND and LND) shows that the proposed CRSA algorithm was better outperformed than other algorithms.

3. PROPOSED EECLOCR PROTOCOL

Energy-Efficient Cross Layer Optimized Clustering Routing (EECLOCR) protocol is presented to organize the Sensor Nodes (SN) into clusters based on K-medoids. Chaotic Pufferfish Optimization Algorithm (CPOA) is introduced which determines the optimal CH, and sensor nodes are paired with the nearest CH. In each iteration, the CPOA algorithm selects a group of CH to construct various cluster networks in an attempt to identify the best possible network configuration. Use the intra-cluster distance, total distance, energy consumption, and residual energy ratio to optimize the selection of CH. It is capable of minimizing transmission distance and optimizing energy efficiency. Thirdly, network overhead is dynamically minimized by using the EECLOCR protocol to find the quickest route.

3.1. Configuration Phase

Depending on the needs of the application, several network configurations can be built; therefore, it is necessary to first define the network's topological structure and assumptions. The sensor nodes attributes make up the network. However, the deployment of nodes in the sensing region is part of the WSN setup in the network structure, which establishes the topological structure where the data will be gathered. The suggested protocol takes into account the network's topology and underlying assumptions. This arrangement has been chosen in order to maintain consistency with similar works. Network presumptions [17],

1. One BS, several CH, and a number of sensor nodes (n) in the network.
2. The sensor nodes have limited energy, but the base station receives its power from an external source.
3. When a sensor node loses power, it is deemed dead.

4. Every sensor node is identical Organization of networks,

   a. At the beginning of the network, every node is placed in the sensing region at random.

   b. Nodes locations won't alter over time.

   c. The center of the sensing area d is where the base station is located. There is no defined number of clusters.

   d. Each normal node, also known as a leaf node, is added to the cluster head that is closest to it. Following the determination of the network topology, the setup step of the network connection establishmentprocedureiscarried out.

   e. The first CH is selected to construct the first cluster network configuration during the setup stage.

   f. The suggested method takes into account the following energy consumption model while choosing the best CH.

3.2. Energy Consumption Model

In WSN, data transmission and reception are the most energy-intensive operations. Equation (1) defines the energy needed to transmit a l-bit data packet [17],

$$E_{TX}\grave{A}(1,d) = \begin{cases} lE_{elec} + l\varepsilon_{fe}d^2, d \leq d_{th} \\ lE_{elec} + l\varepsilon_{mp}d^4, d > d_{th} \end{cases} \tag{1}$$

Where $d_{th}$is the distance threshold during data transmission in equation (2) [17], $\varepsilon_{fs}$is denoted as the energy dissipation during free space model, $\varepsilon_{mp}$is denoted as the energy dissipation during multi-path attenuation model, and $E_{elec}$is is denoted as the energy for transmitting or receiving 1 bit of data.

$$d_{th} = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \tag{2}$$

Equation (3) computes the energy needed to receive a l-bit data packet.

$$E_{RX}(l) = lE_{elec} \tag{3}$$

Since a typical sensor node $n_i$solely sends data to the CH, its energy consumption may be determined using equation (4) [17],

$$E(n_i) = E_{TX}(l, d) \tag{4}$$

Equation (5) can be used to calculate a CH$_j$ energy consumption.

$$E(CH_j) = E_{RX}(l)N_j + (N_j + 1)lE_{DA} + E_{TX}(l, d) \tag{5}$$

where E_{DA} is the energy required for one bit of data aggregation and $N_j$is the no. of member nodes in cluster j. Equation (6) can be used to estimate the residual energy of a sensor node, n_i taking into account the previously mentioned factors [17].,

$$E_r^i(n_i) = \begin{cases} E_r^{t-1}(n_i) - E_{TX}(l, d), E_r^{t-1}(n_i) > 0 \\ 0, E_r^{t-1}(n_i) \leq 0 \end{cases} \tag{6}$$

Equation (7) [17] describes the residual energy of a CH_j,

$$E_r^t(CH_j) = \begin{cases} E_r^{t-1}(CH_j) - E(CH_j), E_r^{t-1}(CH_j) > 0 \\ 0, E_r^{t-1}(CH_j) \leq 0 \end{cases} \tag{7}$$

On the other hand, a leaf node will not be a part of a group if it is farther from its nearest CH than it is from the BS. Rather, it will send the data directly to the BS.

3.3. K-Medoids clustering

CH is selected for every cluster in the WSN when the sensor nodes are grouped together using the clustering. Data collection from certain cluster nodes and transmission to the BS constitutes the CH major task. K-medoids technique divides every sensor node into k clusters. Under the K-medoids approach, every cluster is linked to a single item. As the most central point of the cluster, the detected object is known as a medoid. K-medoids group is associated to each cluster node, finds the best center, hence it is the cluster with the shortest distance between clusters [10, 17],

Step 1: Choose k points at random from the input data.

Step 2: The cluster with the closest center point is assigned to each data point.

Step 3: Compute and add the distance between each data point in cluster "i" and all other data points.

Step 4: Continue from steps 1 through 3 until convergence is achieved. Sensor nodes are grouped together using the clustering approach, and CHs are chosen for each group inside the WSN. Equation (8) is used to determine the first CH node and estimate the number of clusters.

$$c = \sqrt{\frac{n}{2}} \tag{8}$$

where the number of nodes is indicated by n. For each node establish the initial centroid and center location (L),

$$L = \frac{\sum_{n=1}^{N} x_n}{n} \tag{9}$$

where$x_n$stands for the sensor's coordinate. Equation (10), represents the average gap among the SN & L.

$$D = \frac{\sum_{n=1}^{N} |x_n - L|}{n} \tag{10}$$

This leads to the formation of clusters, which are then utilized for CHE.

3.3.1. Operation Phase

After the best CH have been chosen and the network connections have been made, the data is sent to the BS during the operation phase. Every round, data transmission takes place, with one round ending when information moves from regular nodes to CH and finally to the BS. The network is reconfigured using the CPOA algorithm to choose the new, optimal CH and reconstruct the network linkages after every round.

3.3.2. Selection of Optimal Cluster Heads

Which nodes will be chosen to be CH and how many CH there are decided by the CPOA algorithm. Two primary factors are taken into account in the choosing process: the distance between CH and the BS and the remaining energy of CH. In reference to the initial criterion, the establishment of the most efficient link will facilitate energy conservation. Consequently, shortening the links length is taken into account when choosing CH. With respect to the second criterion, the suggested approach identifies sensor nodes as CH if their residual energy is sufficiently high. As per the energy consumption model, CH uses energy for collecting, aggregating, and transferring data, which means that it consumes more energy than conventional nodes. For load balancing, the sensor nodes with the largest residual energy must be chosen as the CH. The CPOA algorithm chooses the best sensor nodes to become CH in each round and automatically determines the ideal number of CH. With this approach, the suggested protocol can be implemented for a variety of WSN applications without having to worry about how many clusters are formed between them. Following the selection of the best CH, every sensor node is integrated into the closest CH. Still, in the event that the sensor node's path to the BS is shorter than its path to the CH, the node is not clustered and its data is sent straight to the BS. Once the clustering process is finished, a possible network configuration is ready to be sent, and its optimality can be assessed.

3.3.3. Selection of Optimal Cluster Network Configuration

In the suggested protocol, by choosing the best group of cluster heads, the CPOA algorithm determines the optimal cluster network configuration C. Cluster heads therefore make it their mission to create a fresh network structure for each iteration. Total intra-cluster distance, total distance from CH to BS, energy consumption, and residual energy of CH are the four terms for fitness calculation. In equation (11) the cost function is defined.

$$f(C) = \omega_1 f_1(C) + \omega_2 f_2(C) + \omega_3 f_3(C) + \omega_4 f_4(C) \tag{11}$$

Where the weighted constant factorsω_1, ω_2, ω_3, and ω_4 regulate how much each component contributes to the formulation. The total intra-cluster distance is computed as follows,

$$f_1(C) = \frac{d_{max}\left(\sum_{j=1}^{k} d\left(n_j, CH_j\right)\right) - \sum_{j=1}^{k} d(n_{j,} CH_j)}{d_{max}(\sum_{j=1}^{k} d(n_j\, , CH_j)) - d_{min}(\sum_{j=1}^{k} d(n_j, CH_j))} \tag{12}$$

The greatest and minimum total intra-cluster distances from each sensor node in$n_j$to its cluster head CH_j are $d_{max}$and d_{min}, respectively. The total distance between the CH and the BS is expressed as follows:

$$f_2(C) = \frac{d_{max}(\sum_{j=1}^{k} d(CH_j, BS)) - \sum_{j=1}^{k}(CH_j, BS)}{d_{max}\left(\sum_{j=1}^{k}(CH_j\, , BS\right) - d_{min}(\sum_{j=1}^{k}(CH_j\, , BS))} \tag{13}$$

In this case, the overall distance from CH to the BS is d. Energy consumption is computed as follows,

$$f_3(C) = \frac{E_{max}\left(\sum_{j=1}^{k}\sum_{i=1}^{N_j} E\left(n_{ij}\right) + E\left(CH_j\right)\right) - E\left(\sum_{j=1}^{k}\sum_{i=1}^{N_j} E\left(n_{ij}\right) + E\left(CH_j\right)\right)}{E_{max}\left(\sum_{j=1}^{k}\sum_{j=1}^{N_j} E(n_{ij})\ + E(CH_j)\right) - E_{min}(\sum_{j=1}^{k}\sum_{i=1}^{N_j} E(n_{ij}) + E(CH_j))} \tag{14}$$

where the energy consumption of sensor node i in cluster j is represented by $E(n_{ij})$. $N_j$is the total number of member nodes in cluster j. The total energy consumption can be expressed as E_{max}andE_{min}, respectively. The residual energy ratio between the members of the sensor node and its CH is added up to the fourth term.

$$f_4(C) = \frac{E_{r_{max}}\left(\sum_{j=1}^{k}\frac{\sum_{j=1}^{N_j} E_r\left(n_{ij}\right)}{E_r\left(CH_j\right)}\right) - E_r\left(\sum_{j=1}^{k}\frac{\sum_{j=1}^{N_j} E_r\left(n_{ij}\right)}{E_r\left(CH_j\right)}\right)}{E_{r_{max}}\left(\sum_{j=1}^{k}\frac{\sum_{j=1}^{N_j} E_r\left(n_{ij}\right)}{E_r\left(CH_j\right)}\right) - E_{r_{min}}\left(\sum_{j=1}^{k}\frac{\sum_{j=1}^{N_j} E_r\left(n_{ij}\right)}{E_r\left(CH_j\right)}\right)} \tag{15}$$

where the members of the sensor node's residual energy is $E_r(n_{ij})$, and the CH residual energy is $E_r(CH_j)$,. E_{max}andE_{min}, respectively, represent the network's maximum and minimum total residual energy. Better cluster network configurations have been produced by the chosen CH by a decreased value of $f(C)$.

3.3.4. Chaotic Pufferfish Optimization Algorithm (CPOA) based CHE

CPOA is introduced for CHE. Because pufferfish move so slowly, predators find them to be an easy target. The pufferfish's sharp spines present an obstacle to the hungry predator rather than an easy meal. When they see this warning, predators become aware of the threat and turn away from the pufferfish. The utilization of the protective mechanism of transforming into a ball of pointed spines to ward off predator attacks is one of the pufferfish's most important natural activities. Other fish behaviors include confrontations with predators.

3.3.4.1. Initialization

With its population search, the POA strategy, a population-based technique, can produce effective CHE.It is an area where problems are solved through an iterative procedure. As a result, every member of POA represents a potential solution to the problem, which may be mathematically characterized as a vector with each element representing a decision variable. The population of the algorithm is made up of all POA members combined. Mathematically speaking, a matrix can be used to represent the community of these vectors as shown by equation (16). Equation (17) is used to initialize each POA member's primary location at the start of the algorithm.

$$X = \begin{bmatrix} X_1 \\ \vdots \\ X_f \\ \vdots \\ X_N \end{bmatrix}_{N\times m} = \begin{bmatrix} x_{1,1} \ldots x_{1,d} \ldots x_{1,m} \\ \vdots \quad \ddots \quad \vdots \quad \iddots \quad \vdots \\ x_{t,1} \cdots x_{t,d} \cdots x_{t,m} \\ \vdots \quad \iddots \quad \vdots \quad \ddots \quad \vdots \\ x_{N,1} \cdots x_{N,d} \cdots x_{N,m} \end{bmatrix}_{N\times m} \tag{16}$$

$$x_{t,d} = lb_d + r.(ub_d - lb_d) \tag{17}$$

In this case, N is represented as the total no. of population members, m is represented as the result variables, $r \in [0,1]$ is a random number, X_i is the ith POA member, and $x_{i,d}$ is its d$^{\text{th}}$ dimension in the CH selection space with their lower and upper bounds are represented as lb_d and ub_d. Equation (18) shows the objective function vector,

$$F = \begin{bmatrix} F_1 \\ \vdots \\ F_t \\ \vdots \\ F_N \end{bmatrix}_{N\times 1} = \begin{bmatrix} F(X_1) \\ \vdots \\ F(X_t) \\ \vdots \\ F(X_N) \end{bmatrix}_{N\times 1} \tag{18}$$

The assessed values for the objective function serve as appropriate benchmarks to assess the caliber of potential solutions put forth by every POA member. The optimal candidate solution, or best member, is represented by the highest evaluated value for the objective function, whereas the lowest evaluated value for the objective function represents the lowest candidate solution, or worst member. The suggested POA approach's architecture updates the population members locations in the problem-solving space by simulating the natural behaviors of pufferfish and their predators. The pufferfish is attacked first by the predator in this natural process. The pufferfish then employs its defense mechanism to become a ball of sharp spines, posing a threat to the predator and allowing it to flee. POA population members with their populations are updated in two stages: (i) exploration, and (ii) exploitation.

3.3.4.2. Phase 1: Predator Attack towards Pufferfish (Exploration Phase)

Using a simulation of the predator's attack plan on the pufferfish, the population's members positions are updated throughout the first phase of POA. Due of their lethargic movement, pufferfish are easy prey for hungry predators. The algorithm for global search gains more exploratory capability when it models the predator's progress near the pufferfish, which causes significant changes in the POA members positions. Equation (19) is used to determine each population member's set of pufferfish.

$$CP_i = \{X_k : F_k < F_i and k \neq i\}, where i = 1,2, \dots., N and k \epsilon \{1,2, \dots, N\} \tag{19}$$

In this case, $X_k$is the population member with a higher objective function value than the ith predator, P_k is its objective function value, and CP_i is the collection of potential pufferfish locations for the i^{th} predator. The picked pufferfish (SP) in the POA design is thought to be the result of a predator's random selection of one of the candidate pufferfish identified in the CP set. Equation (20) is used to determine each POA member new location in the CH search space of the predator's movement toward the pufferfish. Then, equation (21) new objective value is increased in the new position corresponding member's prior position,

$$x_{i,j}^{P1} = x_{i,j} + r_{i,j}.\left(SP_{i,j} - I_{i,j}.x_{i,j}\right), \tag{20}$$

$$X_i = \begin{cases} X_i^{P1}, F_i^{P1} \leq F_i; \\ X_i, else, \end{cases} \tag{21}$$

In this case, $SP_i$is the pufferfish chosen at random for the i^{th} predator from the CP_iset (i.e., SP_i is a component of the CP_iset), $SP_{i,j}$ is its j^{th} dimension, and X_i^{P1} represents the updated location determined for the i^{th}predator using the first phase of the suggested POA; $\boldsymbol{r_{i,j}}$ are random integers from the interval [0, 1],, $x_{i,j}^{P1}$ is its j^{th} dimension, and $F_i^{P1}$is its objective function value.

3.3.4.3. Phase 2: Defense Mechanism of Pufferfish against Predators (Exploitation Phase)

Using a simulation of a pufferfish defensive mechanism against predator attacks, the position of population members is updated throughout the second phase of POA. A pufferfish fills its incredibly elastic stomach with water to defend itself from predators, turning it into a ball of sharp spines. Instead of taking advantage of the easy meal, the predator in this scenario flees from the pufferfish location. Based on equation (22) this new position then replaces the associated member if it increases the value of the objective function. The new role is appropriate for the relevant POA member if the response is affirmative; if not, the member keeps their old position and the new one is improper.Equation (23) illustrates how each POA member's update procedure is dependent on raising the objective function's value.

$$x_{i,j}^{P2}=x_{i,j}+\left(1-2r_{i,j}\right).\frac{ub_{j-}lb_{j}}{t} \tag{22}$$

$$X_i=\begin{cases} X_i^{P2}, F_i^{P2}\leq F_i; \\ \quad X_i, else, \end{cases} \tag{23}$$

Here, $r_{i,j}\in[0,1]$ are random values, t is the iteration counter, $x_{i,j}^{P2}$is the new location estimated for the i^{th}predator from second phase, $x_{i,j}^{P2}$is itsj^{th} dimension, and $F_i^{P2}$is its objective function value.

3.3.5. EECLOCR protocol

Data is transferred across the shortest pathways using the scalable and energy-efficient EECLOCR protocol. It lowers packet delays and improves communication link dependability. Every node broadcasts a HELLO message containing its ID, the path cost, and the number of hops to the base station. If the base station path cost is originally zero and every node is unlimited, it may vary from round to round. The HELLO messages that each node receives determine how it arranges its list of neighbors. Utilizing the received signal strength indicator (RSSI) of incoming messages, signal strength is determined. To serve as the next hop sensor node and transmit data from node n to the BS, a parent $Par(n)$ must be selected for a given sensor node n.

4. SIMULATION AND EXPERIMENTAL RESULTS

Metrics including network lifetime, energy consumption, throughput, PDR, and PLR are used to compare the suggested approach with the current approaches. The proposed method has been evaluated against other widely used methods, including CPMA, EECRP, and E-CERP. For the purpose of experiment consistency, Table 1 parameter settings have been taken into account for each routing protocol under comparison.

TABLE 1. SIMULATION PARAMETERS

PARAMETER	VALUE
Sensing area	500 m × 500 m
Number of sensor nodes N	500
Number of clusters	6
Packet size l	4000 bits
E_{DA}	5 nJ/bit
E_{elec}	50 nJ/bit
ε_{mp}	0.0013 pJ/bit/m^4
Initial energy of sensor nodesE_0	0.07 J

Packet Delivery Ratio (PDR): PDR is the percentage of packets that are delivered to their destination successfully. The ratio of data packets created at the source to those received at the destination is known as PDR. In equation, it is represented by (24),

$$PDR = \frac{Number\ of\ packets\ received}{Number\ of\ packets\ sent} \tag{24}$$

Packet Loss Ratio (PLR): The ratio of the total number of packets transferred to the number of lost packets is known as the packet loss ratio, or PLR. Equation (25), a representation of it,

$$PLR = \frac{Number\ of\ lost\ packets}{Number\ of\ packets\ sent} \tag{25}$$

Network lifetime: The amount of time that passes between the initial nodes death and the network's commencement of operation.

Energy Consumption: In WSN, the quantity and range of data transmissions are the main determinants of energy consumption.

Throughput: The quantity of data packets that the BS receives.

TABLE 2. PDR AND PLR COMPARISON VS. ROUTING PROTOCOLS

Techniques	PDR (%)	PLR (%)

No. of Nodes	**100**	**200**	**300**	**400**	**500**	**100**	**200**	**300**	**400**	**500**
EECRP	94	90	88	87	85	6	10	12	13	15
E-CERP	96	94	92	90	88	4	6	8	10	12
EECLOCR	100	100	97	95	93	0	0	3	5	7

TABLE 3. NETWORK LIFETIME AND ENERGY CONSUMPTION (ROUTING PROTOCOLS)

Techniques	**NETWORK LIFETIME (Rounds)**					**ENERGY CONSUMPTION (mJ)**				
No.ofNodes	**100**	**200**	**300**	**400**	**500**	**100**	**200**	**300**	**400**	**500**
EECRP	4912	4758	4577	4283	4045	8.71	9.37	10.44	11.62	11.96
E-CERP	5394	5125	4929	4713	4357	6.98	7.24	7.46	8.15	8.64
EECLOCR	5949	5736	5562	5278	5095	1.55	2.05	3.18	3.92	4.25

TABLE 4. THROUGHPUT CONSUMPTION OF ROUTING PROTOCOLS

Techniques	**Throughput (Mbps) vs. Rounds**				
No.ofnodes	**100**	**200**	**300**	**400**	**500**
EECRP	0.92	0.90	0.89	0.88	0.87
E-CERP	0.95	0.93	0.91	0.90	0.88
EECLOCR	0.98	0.96	0.94	0.93	0.91

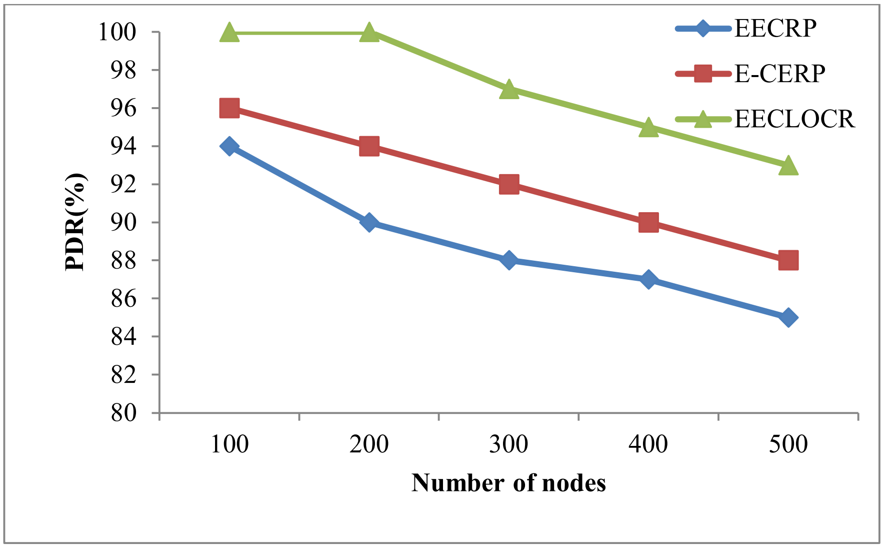

FIGURE 1. PACKET DELIVERY RATIO (PDR) VS. ROUTING PROTOCOLS

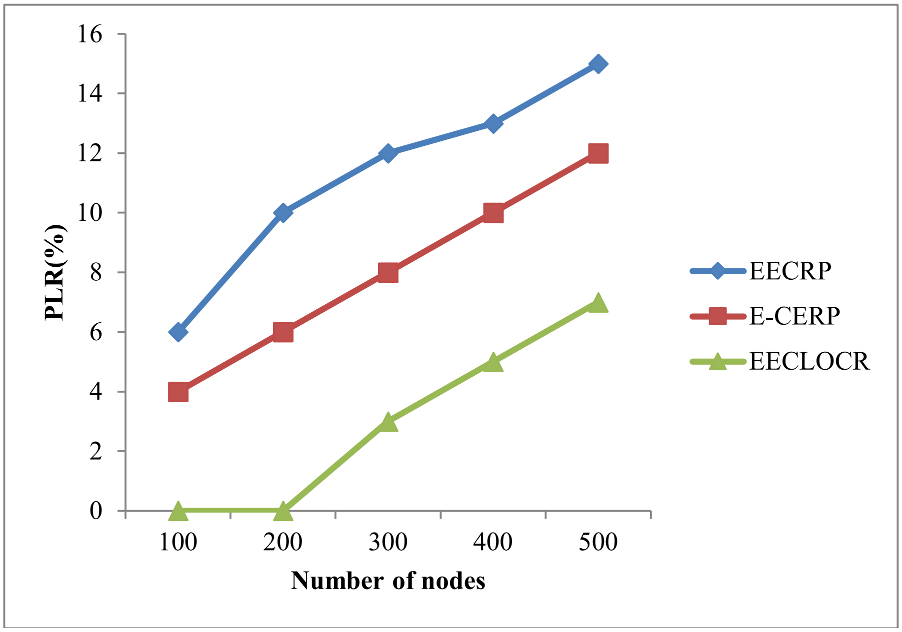

FIGURE 2. PACKET LOSS RATIO (PLR) VS. ROUTING PROTOCOLS

Figures 1 show that the PDR of routing protocols are reduced when the no. of nodes increased. PDR results achieved by 100 nodes were 94.00%, 96.00% and 100.00% like EECRP, E-CERP and EECLOCR (Refer Table 2). PLR comparison of routing protocols is illustrated in Figure 2. For 100, and 200 nodes, the proposed protocol obtained 0.00% PLR, and the existing methods like EECRP, E-CERP achieved higher PLR values of 6.00% and 4.00%, respectively (Refer Table 2). Results show that the proposed method considerably reduced PLR than other methods.

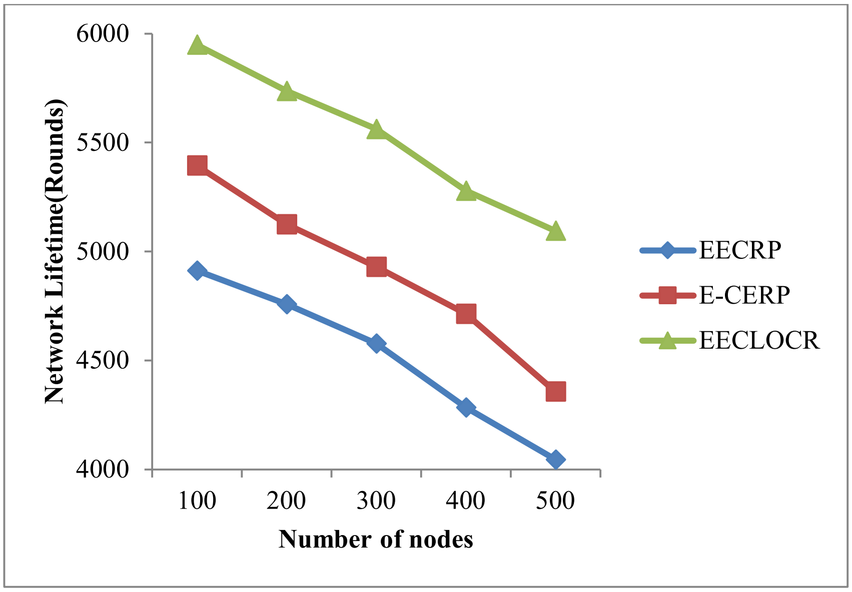

FIGURE 3. NETWORK LIFETIME VS. ROUTING PROTOCOLS

Routing protocols with respect to network lifetime is illustrated in Figure 3 and Table 3.It shows that the network lifetime of proposed system is extended for 100 nodes (5949 rounds). EECRP, E-CERP approaches are 4912 rounds and 5394 rounds respectively (Refer Table 3). Furthermore, as the no. of nodes increased, the network lifetime of the routing protocols has been decreased.

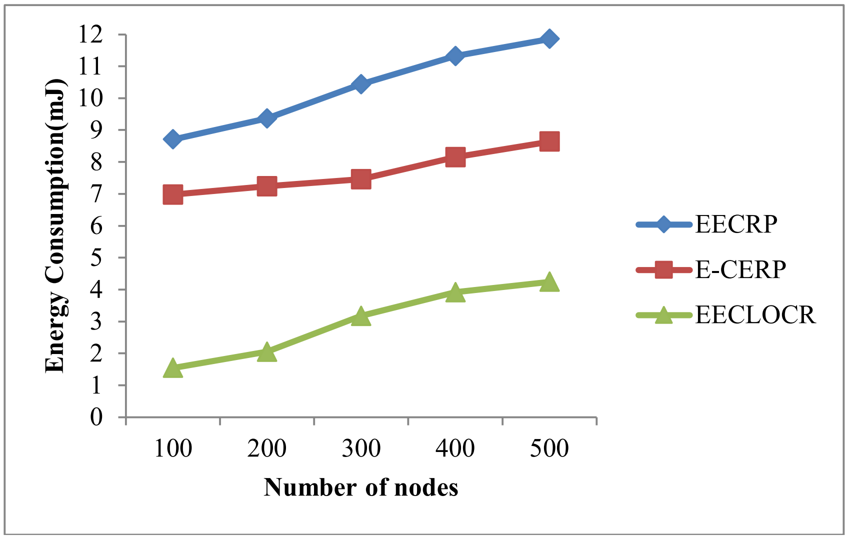

FIGURE 4. ENERGY CONSUMPTION VS. ROUTING PROTOCOLS

Energy consumption of the routing protocols is shown in Figure 4 and Table 3. Simulation results it shows that the proposed system had consumed lesser energy (1.55 mJ), EECRP, E-CERP approaches consumed 8.71mJ and 6.98mJ. For 200 nodes, the proposed approach consumed

2.05mJ of energy, and methods like EECRP, E-CERP consumed 9.37mJ and 7.24mJ of energy respectively (Refer Table 3).

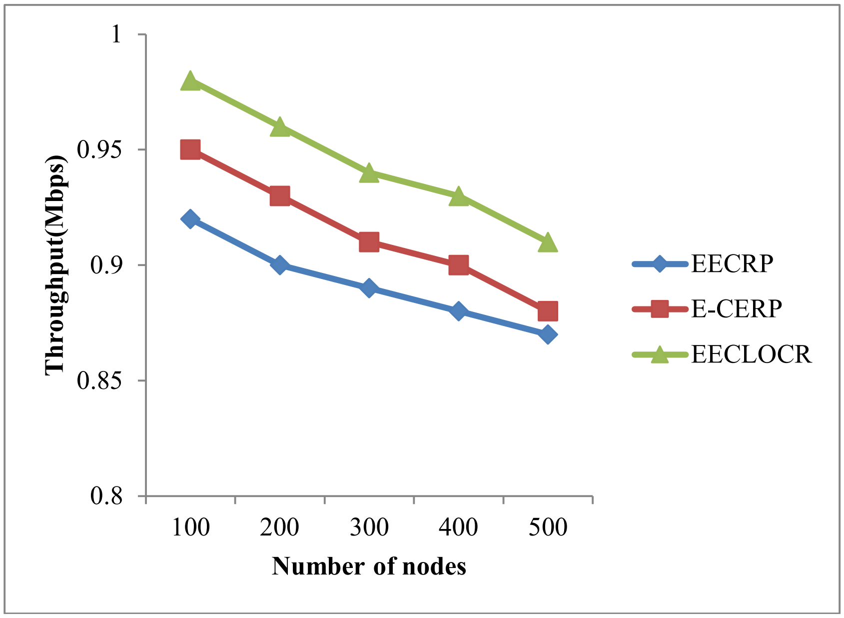

FIGURE 5. THROUGHPUT CONSUMPTION VS. ROUTING PROTOCOLS

Figures 5, and Table 4, show the results comparison of proposed routing and existing routing methods via throughput. Throughput results achieved by proposed system are 0.91 Mbps, conventional methods like EECRP and E-CERP are 0.87 Mbps and 0.88 Mbps for 500 nodes (Refer Table 4).

5. CONCLUSION AND FUTURE WORK

In this paper, Energy-Efficient Cross Layer Optimized Clustering Routing (EECLOCR) protocol is introduced for WSN. K-medoids are introduced to group the SN into clusters. Then, the no. of CH and optimal CH is chosen by the CPOA, at the same time as sensor nodes are allocated to its adjacent CH. CPOA algorithm also discovers new best cluster network configuration by choosing the best CH. New network structure is found by CH. Predators with CPOA can sense danger and disengage from the pufferfish. The utilization of the protective technique of transforming into a ball of pointed spines to ward off predator assaults is one of the pufferfish's most important natural activities, along with disputes with other fish. CH is elected through intra cluster distance, total distance, energy consumption and residual energy ratio. It is able to make best use of the energy efficiency and reduce the transmission distance. EECLOCR protocol data is transmitter over shortest paths with energy efficiency and scalable way. The proposed method and existing methods are evaluated using the metrics like PDR, PLR, Network lifetime, Energy Consumption and throughput. It is extended to mobile sensor nodes/other networks by sensors with the purpose is be able to modify position in real-time.

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