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Modified Dolphin Search Based Energy Efficient and Secured Routing Protocol for Wireless Sensor Network

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Abstract: As sensor nodes sense and monitor the physical or environmental variables and broadcast the providing data to the base station using multihop routing, wireless sensor networks (WSNs) are emerging as one of the most demanding platforms. Various group methods have been established subsequently to increase network lifespan and reliability, although the majority of these systems require simply a distance parameter for data transfer in homogenous networks. In the existing work, Improved sparrow search based Cluster Head selection method is introduced. Choosing the next hop depending on the energy factor has been improved by various current techniques, however these solutions are unreliable and don't reduce data delivery interruptions on overcrowded networks. In this work, Modified Dolphin Search based Energy Aware Secured Multi-Hopfor the best clustering choosing and safe data transfer, the MDSEASM-KEM routing protocol, a mix of K-means and expectation-maximization technique, is developed. In MDSEASM, the whole network area is divided up into sectors, and inside each sector, a mobile sensor node that will act as a Mobile Data Collector (MDC) will be placed in order to collecting data from CHs. After the installation of sensor nodes and the building of clusters, this step is carried out. This method dramatically lowers the amount of energy used by sensor nodes to transmit data to the base station (BS). The Fuzzy Squirrel Search Algorithm (FSSA), which finds paths while taking energy usage into account, is also suggested for routing. The following Quality of Service (QoS) factors are taken into account in this study effort for the best route path selection: network longevity, stability, throughput, number of CHs and number of dead nodes, Energy, and packet loss. The NS2 simulation environment is used for the overall analysis of the study effort, and it has been shown that the suggested technique produces superior results than the current methods.

Keywords: *Wireless sensor network, modified dolphin search algorithm, squirrel search algorithm, cluster head selection, clustering*

1. Introduction

A WSN is characterised as a network of tiny, autonomous devices known as sensor nodes [1]. To collect sensory data over the whole network field, all installed sensor nodes are spread at random based on ad-hoc architecture [2]. Due to limited resources, WSNs, unlike other wireless communication technologies, place special restrictions on the communication protocols [3]. In conventional networks, routing protocols are created to enhance network efficiency in terms of the transmission of data and the latency of the network. WSNs, on the other hand, are primarily concerned with advancing methods of energy conservation while simultaneously reducing communications overheads [4]. Scalability, low costs, accuracy, stability, and ease of dissemination are the main benefits of WSN applications over traditional networking strategies [5]. Energy usage is a scarce resource in WSN settings [6] because to the tight limits, and it must be managed carefully to extend network lifespan and improve routing efficiency. Due to the dynamic nature of sensor nodes, traditional and single layer routing techniques are impractical for sensor-based applications. Thus, in recent years, several researchers [7] have concentrated on creating an adaptable and reliable routing protocol to increase resource economy and find the best paths to the endpoints.

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Hierarchical-based routing techniques enhance discovery of routes and energy efficiency in wireless sensor networks [8]. These kinds of approaches are helpful for scaling up to hundreds or thousands of sensor nodes while maintaining efficient load control [9]. The hierarchy network consists of network panelling and data transmission. Previous hierarchy approaches involve stochastic approaches and sub-optimal panels [10]. Existing systems [11] don't maximise route finding for adaptive wireless connections and conduct periodic re-clustering. In order to construct a data propagation route from beginning to finish, route demand packets must be flooded hop-by-hop, which increases communications costs and network lifespan [12]. Energy-constrained systems need energy-efficient and resilient routing protocols. Optimal routing route selection and adjusting for data dissemination are also difficult. [13].

A system that can ensure safe and energy-efficient routing in wireless sensor networks is the primary aim of this study project's effort to develop such a technique. In order to pick the best cluster head and transmit data securely, the Modified Dolphin Search based Energy Aware Secured Multi-hop Routing utilising hybrid K-means and Expectation-Maximization Technique (MDSEASM-KEM) routing protocol is developed.

Following is a description of how the research activity is organized overall: In this part, a comprehensive introduction to the wireless sensor network is provided, along with the requirement for energy. Different research approaches have been thoroughly examined in section 2 in terms of how they operate. The suggested technique is covered in full in section 3 along with pertinent numbers and examples. Results and comments are given in section 4 to analyses the efficiency improvements. Section 5 of the study work provides a final analysis.

2. Related Works

Haseeb et al [14] create an energy-efficient and secure routing protocol (ESR) for Internet of Things intruder prevention based on wireless sensor networks (WSN) to lengthen the lifetime of the network and increase the dependability of the data. The lifespan of the network, the typical end-to-end latency, the packet delivery ratio, the typical communication cost, the network overhead, and the number of times that routes need to be rediscovered were all improved by the proposed routing protocol when compared to the work that has been done so far under dynamic network topologies, according to experimental results using the network simulator (NS-2).

Ganesh et al [15] in order to improve ad hoc on-demand distance vector routing, dynamic clustering that is determined by signal-to-noise ratio was included as an additional feature (SNR). The proposed technique may group the nodes into clusters, choose the node that will serve as the cluster head (CH) based on the energy of the nodes, and then have non-CH nodes link with a specific CH according to the SNR values of those nodes. This approach is a wireless sensor network routing system that is both reliable and efficient.

Ganesh et al [16] extended by incorporating optimum signal-to-noise ratio (SNR)-based power management mechanisms and optimal handoff-based self-recovery characteristics, the Modified triple umpiring system (MTUS) was designed in order to provide a safe and efficient routing solution for wireless sensor networks (WSN). Extensive research tests utilizing the Glomosim-2.03 Simulator demonstrate that the power consumption may be greatly decreased by employing the efficient and secure routing protocol (ESRP) has the most effective power management system and self-recovery that is based on handoffs.

Santhosh Kumar et al [17] proposed using the cutting-edge Secured-Selective Design Relay Inquiry Protocol (S-SELDRIP), which offers secure optimum routing via hop-by-hop identification during data dissemination Considerations of potential weaknesses during the data transmission and the degree to which the suggested system is able to resist them have been taken into account in order to examine the viability and effectiveness of the S-SELDRIP system.

Liu et al [18] seeks to maximize network security and longevity while taking energy restrictions into account. The Security and Energy-efficient Disjoint Route (SEDR), a three-phase disjoint routing architecture, is suggested to achieve this. In the first two stages, the SEDR system dispersive and randomly distributes shares around the network depending on the method for exchanging secret, prior to transmitting these shares to the sink node.

Sharma et al [19] proposed symmetric key cryptography-based energy-efficient safe routing for wireless networks. The session-based crypto system that is being suggested changes the session key once each session has ended. We pick a cluster head for each cluster after dividing the network into a number of groups. There are three levels of interaction among the sensor and the sink: sensor! sink, you cluster-head.

Kim et al [20] reduced the amount of energy required by certain nodes in a WSN, as opposed to data secured using a symmetric key, which must be decrypted and encrypted at each node along its route. Data that has been encrypted using a public key is just sent from one intermediary node to the next. We simulated the use of either symmetric-key or public-key encryption on its own and compared it to our method, which was proven to be more secure, more energy-efficient, and less prone to node blackouts than the other systems.

Zhou et al [21] BEARP, the neighbor discovery, the routing discovery, and the routing maintenance stages are the three components that make up a three-phased routing protocol for wireless sensor networks. This protocol is both effective and secure, and it is founded on encryption and authentication. BEARP maintains the four safety aspects of routing data secrecy, authentication, integrity, and freshness by encrypting all communications packets and authenticating the source nodes and base station (BS).

Miglani et al [22] The LEACH protocol has been improved by adding trust to offer safe routing while preserving its uniqueness with the proposed energy-efficient and trust-aware framework for LEACH (EETA-LEACH). This strategy combines a trust management module and a trust-based routing module that cooperate to choose a trustworthy Cluster Head (CH).

Ferng et al [23] improves energy balance, routing efficiency, and delivery rate. Additionally, the suggested security method guarantees data delivery secrecy and validity. Simulating and analyzing the suggested protocol, we demonstrate that it can greatly outperform the nearest routing protocol and security mechanism.

Prithi et al [24] Novel LD2FA (Learning Dynamic Deterministic Finite Automata) has been presented to cultivate the network's dynamic character. To counter this, LD2FA - PSO offers details on node, packet, and route inspection for the purpose of identifying and removing intruders, enabling data transfer via the most energy-efficient route. The total performance of the sensor network is improved by routing via the best way, which has been investigated utilizing a number of different metrics, such network longevity, performance, and energy usage, living and dead nodes.

Selvi et al [25] The trust score assessment is utilized to identify malicious users in WSN efficiently, and decision tree method is employed with spatio-temporal restrictions to choose the optimum route in the newly suggested energy conscious trust based safe routing algorithm. It has been shown via testing that the suggested trust-based routing algorithm outperforms current systems in terms of safety, efficiency in using energy, and the ratio of packets delivered.

3. Energy Efficient and Secured Routing Protocol

In this study, a new routing protocol called Modified Dolphin Search based Energy Aware Secured Multi-hop Routing utilising hybrid K-means and Expectation-Maximization Technique (MDSEASM-KEM) is developed for the best clustering choice and safe information transfer. The entire networking region in MDSEASM is split into parts following the installation of sensor nodes and the establishment of groups, and every region is then home to a mobile sensor node that serves as a Mobile Data Collector (MDC) for gathering information from CHs.This method dramatically lowers the amount of energy used by sensor nodes to transmit data to the base station (BS). The Fuzzy Squirrel Search Algorithm (FSSA), which finds paths while taking energy usage into account, is also suggested for routing. The following Quality of Service (QoS) factors are taken into account in this study for the best route path selection: network lifespan, stability, throughput, number of CHs, and number of dead nodes. For assessment reasons, consider energy and packet loss.

3.1. RADIO ENERGY MODEL

The total amount of energy lost through transmission among the transmitters and the reception is calculated using the radio energy model. The quantity of energy wasted by the transmitters ETX and the receiver ERX in this study is calculated using both the free space model and the multi-path model (Fig. 1), and it relies on the range d among them [18].

The energy required to transmit provided is the K-bit of information travelling d meters (1):

$$E_{TX}(K,d) = \begin{Bmatrix} K.E_{elec} + K.\varepsilon_{fs}.d^2 & if\ d \le d_0 \\ K.E_{elec} + K.\varepsilon_{mp}.d^4 & if\ d > d_0 \end{Bmatrix} \quad (1)$$

where E_{elec} is the amount of power needed to operate both the transmitters and the receiving per bit, ε_{fs} and ε_{mp} are Energy needed for transmitters model amplification across distance d, using the free space or multipath models, accordingly.

The energy required for the free space model in this case is equivalent to d^2 ($if\ d \le d_0$) Additionally, the multipath model's proportionality d^4 $(if\ d > d_0)$ due to the fact that the sending signal takes multiple routes to get to BS level. By bringing together the two equations of $E_{TX}(K,d)$ at $d = d_0$ we get d_0 where $d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$ is threshold distance. if the threshold range is not met by the transmitting range (d_0) The multipath model is employed unless the free space model is used. Energy consumption for processing K-bit messages is determined using (2):

$$E_{RX} = L.E_{elec} \quad (2)$$

Suppose the 'n' SNs that are arbitrarily scattered around the network field's area (A) of $M \times M$ metres square. Assuming, for the purpose of simplicity, that the BS/Sink is located in the centre of the network field and that the shortest range between any SN and that BS is, the following calculations will be performed $< d_0$. As a result, (3) provides the quantity of energy lost by the CH node in a round.

$$E_{CH} = K.E_{elec}\left(\frac{n}{k} - 1\right) + K.E_{DA}.\frac{n}{k} + K.E_{elec} + K.\varepsilon_{fs}.d_{toBS}^2 \quad (3)$$

When there are k groups,, E_{DA} is the price of data gathering and d_{toBS} is the separation between CH and BS. The following formula gives the quantity of energy used by a non-CH node (4):

$$E_{nonCH} = K.E_{elec} + K.\varepsilon_{fs}.d_{toBS}^2 \quad (4)$$

where d_{toCH} is the separation among sensor nodes on the CH and group members. (5): If the distribution of all sensor nodes is consistent.

$$E[d_{toCH}^2] = \iint (x^2 + y^2)\rho(x,y)dxdy = M^2/(2.\pi.k) \quad (5)$$

Where $\rho(x,y)$ is how the sensor nodes are distributed. Within a group, there is an energy loss of (6) each season:

$$E_{Cluster} \approx E_{CH} + \frac{n}{k}.E_{nonCH} \quad (6)$$

Therefore, (7) gives the aggregate amount of energy that is frittered away over the entire network:

$E_{total} = K.(2n.E_{elec} + n.E_{DA} + \varepsilon_{fs}\left(k.d_{toBS}^2 + n.\frac{M^2}{2.\pi.k}\right))$ (7)

Now distinguish E_{total} w.r.t k and make it equal to zero, the best amount of groups to create is provided by (8):

$$k_{opt} = \sqrt{\frac{n}{2}}.\frac{M}{d_{to\,BS}} = \sqrt{\frac{n}{2}}.(\frac{2}{0.765}) \quad (8)$$

Additionally, (9) provides the average separation among CH and BS:

$$E[d_{toBS}] = \int_A \sqrt{x^2+y^2}.\frac{1}{A}.dA = 0.765.M/2 \quad (9)$$

The best chance is thus (p_{opt}) is provided by of sensor node to be CH (10):

$$p_{opt} = k_{opt}/n \quad (10)$$

3.2. Determination of Similarity Functions in Cluster-Based Wsn Data Aggregation

There are multiple cluster members and a cluster head (CH) in each cluster (CMs). After a cluster has been formed, a CH is in charge of gathering data from its CMs and sending it to the sink/BS. Data aggregating is a crucial method in cluster-based UWSNs since CHs and aggregates exhibit behaviours that are quite comparable. Four resemblance functions—distance, Euclidean's cosine distance, Jaccard's distance, and Hamming distance—that are focused on data aggregating in cluster-based WSN are taken into consideration.

The optimal matching function for data integrating in cluster-based wireless sensor networks was identified using normalized thresholds, which we obtained for each function in the article. By lowering packet size and eliminating data redundancies supplied to the sink/BS, our study found that the Euclidean and cosine ranges may assist cluster-based UWSNs function more effectively. There are multiple cluster members and a cluster head (CH) in each cluster (CMs). A CH is in charge of gathering data from its CMs and sending it to the sink/BS when the cluster has been formed. Data aggregating is a key strategy in cluster-based WSNs since CHs and aggregates behave in very equivalent ways. Four similarities functions were investigated in current research works that focused on data aggregating in cluster-based WSNs.We established normalized thresholds for each function in this research so that we could determine which of the similarity functions offers the most advantageous choice for data integration in cluster-based wireless sensor networks. This analysis found that by lowering packet size and eliminating data redundancies provided to the sink/BS, the Euclidean and cosine distances may enable cluster-based WSNs function more effectively.

The location of a node is important in WSNs. A node regularly records events at every point and transmits the recorded data to the aggregate. One of the essential functions of the aggregators is data aggregating. By removing data redundancies, the network's total energy usage is reduced, and the size of the packets sent to the sink/BS is also decreased. The location of a node is crucial in WSNs.A node regularly records events at every point and transmits the recorded data to the aggregate. One of the essential functions of the aggregate is data aggregate. By removing data redundancy, the network's total energy usage is reduced, and the size of the packets sent to the sink/BS is also decreased. A collection of measurable data is gathered and stored as a vector by each aggregator at a certain moment in data aggregating.The aggregator then finds sets of pairings that have more similarity than a specified threshold. For the aggregator, using a similarities function is therefore a viable strategy. A threshold is used by a similarity function to determine how similar two sets of data are. We employ similarity functions to aggregators to advance the aim of decreasing network utilization as well as the dimensions of the data packets. The aggregator need not send all sets of data to the sink/BS if it is determined that the comparison data are equivalent to one another.

An aggregator's primary duties include gathering sensed data from nearby nodes, storing acquired data, employing similarities functions to compare two different sets of data, namely the present data set and the new data set, as well as data transmission to the sink/BS. An aggregation saves the gathered data as a vector in the order of the neighboring nodes in order to do the evaluation. To assess the degree of similarities among two data sets, an aggregator performs a similarities function. If it is found that the two data sets are quite comparable to one another, the aggregate will only transmit one of the data sets to either the sink or the BS rather than both of them. In the event that this is not the case, it transmits all of the data to the sink or BS.

Let p,qbe the two collections of data, with $p = \{p_1, p_2, \dots p_n\}$is a group of already gathered information, $q = \{q_1, q_2, \dots, q_n\}$is a brand-new dataset, and n is the quantity of neighbors. Any resemblance function may be used as the SF function; here, we'll briefly explore the cosine and Euclidean distances. Other resemblance measures that may be used to set comparison include edit distance, extended edit distance, Euclidean distance, cosine distance, and Jaccard's similarity. The Euclidean distance and cosine distance, however, are two suitable resemblance functions for WSNs, according to study.

Here, we go into great depth on how the Euclidean distance and the cosine distance function, as well as how each one influences the network in its own unique way.

Each individual set of data in the dataset consists: compared against each other using the Euclidean distance, which is determined by

$$E_d = \sum_{i=1}^{n} \sqrt{(p_i - q_i)^2} \quad (11)$$

Thus p and q are said to be similar if $E_d \leq t_d$.

One sort of resemblance is a number that represents the cosine of an angle created by two vectors. a value equal to one minus the cosine of the angle created by two vectors is the cosine distance, which is denoted by

$$C_d = 1 - \frac{\sum_{i=1}^{n}(p_i \times q_i)}{\sum_{i=1}^{n}(p_i)^2 \times \sum_{i=1}^{n}(q_i)^2} \quad (12)$$

Consequently, p and q are considered comparable if$C_d \leq t_d$.

The obtained values are used immediately to determine the divergences among pairs of data employing the cosine distance as well as the Similarity measure. The Euclidean distance is an estimate of the distance between two vectors when measured in a straight line, while the cosine distance primarily bases its calculation on the angle between two vectors. As a result, distinct values are produced that need to be scaled for comparison; normalization is the fundamental technique for doing this. For certain purposes and domains, vector normalization has been the subject of some study. Understanding how normalization affects the distance data is crucial. To enable precise compares between those vectors, all vectors are scaled to have the same variance.

The normalizing equation is shown by

$$t'_d = \frac{t_d - m}{6\sigma} + \frac{1}{2} \quad (13)$$

Where the parameter t_d indicates the initial paired range threshold value, $t'_d$the normalised range valuation, m the mean value, and the standards deviations of the data

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(t'_{di} - m)^2}{n}} \quad (14)$$

As a result, sensor data are collected and sorted according to resemblance values. Then MEACBM will be applied for each group of this data to get compressed data which will then be forwarded to other nodes.

3.3. MULTI-HOP ENERGY EFFICIENT ROUTING PROTOCOL USING MULTIPLE MOBILE NODES USING HYBRID OF K-MEANS AND EXPECTATION-MAXIMIZATION (KEM) APPROACH (MEACBM-KEM) IN WIRELESS SENSOR NETWORKS

For each collection of sensor data, the MEACBM will be used to compress the data before sending it to additional WSN nodes. As is the case today with WSNs, the primary goal is to enhance the network's longevity and security via energy efficiency. Mobility is the greatest solution for it. Because if mobility is lacking, there is a higher chance that the network will have coverage gaps.When the network is operational but there are a few sensor nodes whose energy needs are not being met, coverage gaps will result drops to an extremely low level and they die, leaving that area unmanaged and making it challenging must keep an eye on that region, which is connected to an energy holes' issue. In such instance, mobility effectively reduces the issue of coverage gaps and balances the amount of energy that is used by the sensor nodes. The concept being put forward MEACBM hierarchical heterogeneous cluster-based routing protocol focuses on energy economy in routing by adding a term S(i). E to the probabilities equation in such a way that only the sensor node remains with the most energy is picked as Cluster Head (CH). This technique improves network longevity, scalability, connection, and energy efficiency by lowering sensor node energy usage.

3.3.1. CLUSTER HEAD SELECTION USING MODIFIED DOLPHIN SEARCH ALGORITHM

This study uses a modified dolphin method to choose cluster heads. Wu et al., motivated by PSO, studied dolphin behaviour in 2016. The dolphin hunts using echolocation. Dolphin swarms cooperate and divide work to collect prey besides echolocation. Dolphin swarms communicate information, thirdly.One dolphin finds prey, tells others using echolocation, and subsequently all dolphins collect food. Initialization, search, call, reception, predation, and termination are the DSA's six steps. Since the beginning stage is merely population initialization, the end stage only offers a termination condition, search, call, reception, and predation are mostly utilized in this paragraph.

Sensor nodes in WSNs may have varying beginning energies, heterogeneous wireless sensor networks are the name given to these specific kinds of networks. The MEACBM algorithm takes into consideration the three various energy levels of the sensor nodes and distributes them across the network. The energy of a typical sensor node is indicated by and its number is N E_0, Advance nodes are a fractional of a node called "m" from a node called a sensor, and they possess a time-dependent increase in energy. $E_0(1+\propto)$. Compared to regular in addition to the sensor nodes that make up the network, intermediate sensor nodes also exist 'x' times smallerβcomparing to standard sensor nodes, requires time more energy i.e. $E_0 = 1 + \beta$. This means that the network's total number of advance sensor nodes is provided by (15):

$$Total_A = N.m \quad (15)$$

where N represents all of the network's sensor nodes.

The network's intermediary sensors are described by (16):

$$Total_I = N.x \quad (16)$$

Standard sensor nodes are provided by (17):

$$Total_N = N.(1 - m - x) \quad (17)$$

Advanced sensor nodes get their initial energy from (18):

$$E_A = Total_A * E_0(1+\propto) = NmE_0(1+\propto) \quad (18)$$

Advanced Sensor nodes get their initial energy from (19):

$$E_I = Total_I * E_O(1 + \beta) = NxE_0(1 + \beta) \quad (19)$$

And the starting energy of the Standard Sensor nodes is provided by (20):

$$E_N = Total_N * E_0 = N(1 - m - x)E_0 \quad (20)$$

Thus, the particular starting energy levels of the standard, intermediary, and advanced sensor nodes are added to get the overall initial energy level of heterogeneous WSNs, (21) and (22).

$$E_{Total} = E_A + E_I + E_N \quad (21)$$

$$E_{Total} = NmE_0(1+\propto) + NxE_0(1 + \beta) + N(1 - m - x)E_0 \quad (22)$$

In light of this, the suggested three level heterogeneous WSN includes $NmE_0(1+\propto) + NxE_0(1 + \beta) + N(1 - m - x)E_0$ compares to homogenous WSN with times greater energy E_0 identical numbers of sensor nodes at initial energy level.

As a result, the network will enter a new era following the addition of three distinct SN kinds (23)

$$\frac{1}{P_{opt}}.(1+\propto.m + x.\beta) \quad (23)$$

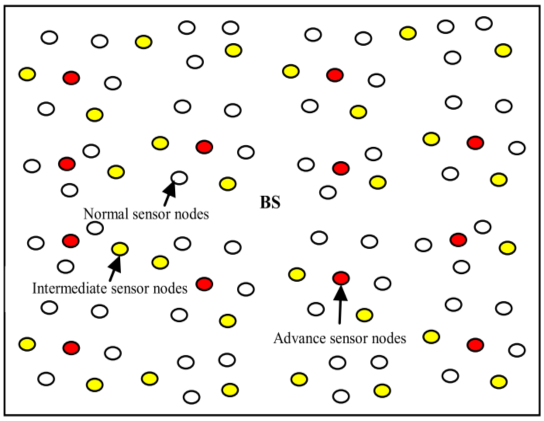

Fig. 1. Deployment of sensor nodes in network area

The network's SNs have been randomly distributed, and MEACBM has begun its Set-up phase (Fig. 1). Each sensor node generates an arbitrary number values among 0 and 1, and if that value is smaller than the MEACBM threshold value, that sensor node is only chosen as the CH for that round.

The new threshold value of EACBM is given by (24):

$$T_{(n_z)} = \begin{cases} \frac{P_z}{1-P_z(r*mod(\frac{1}{P_z}))} * [S(i).E] & if \quad n \in G^z \\ 0 & otherwise \end{cases}$$
(24)

where P_z is the probability that the given number of sensor nodes will be chosen as CHs; Z may be nrm, int, or adv for each regular, intermediate, or advanced SN; r is the round's total; and G is the configurations of SNs that weren't chosen as CHs in the previous P rounds. In contrast to previous cluster-based routing protocols, MEACBM's threshold value indicates the sensor node's current energy and suggests that only high energy sensor nodes should be CH rather than low energy sensor nodes.

According to our suggested protocol, there are on average CHs in each round and epoch as follows: $(1+\propto.m + x.\beta)$.As a result, each of the three categories of sensor nodes should have the following election chances: P_N (25), P_I (26) and P_A (27) respectively are:

$$P_N = \frac{P_{opt}}{(1+\propto.m+x.\beta)} \quad (25)$$

$$P_I = \frac{P_{opt}(1+\beta)}{(1+\propto.m+x.\beta)} \quad (26)$$

$$P_A = \frac{P_{opt}(1+\propto)}{(1+\propto.m+x.\beta)} \quad (27)$$

where P_N; P_I and P_A are the odds of choosing a normal, intermediate, or advanced sensor node separately, and Poptis is the best chance of choosing a CH sensor node. Once chosen, it advertises to the other sensor nodes in the network region that it is the CH for that specific round. To do so, each CH creates an advertising message (Advmsg) containing a non-persistent Carrier Sense Multiple Access (CSMA) MAC protocol, a CH-ID, and an Adv Header.Every non-CH sensor node chooses to join to one cluster over another based on the CH Advmsg received signal strength (RSS), and it must inform the relevant CH of its choice. Every non-CH sensor node of the cluster must use the CSMA MAC protocol to transmit its join request message (join-REQ) to its associated CH. The member sensor nodes ID, related CH-ID, and header are required components of this join-REQ message. Once clusters have been established, each CH is required to establish a TDMA schedule within the confines of its own cluster, with a time slot designated for the gathering of data supplied by each sensor node that is a part of the cluster. Each TDMA frame length in this case has an additional time slot built in so that CH may send its gathered data to BS in an aggregated form.the quantity of sensor nodes included inside every group in addition to one frame for the CH of every group, determines how long this frame will be. In addition, it's conceivable that certain sensor nodes randomly deployed throughout each cycle have not yet joined any clusters or have been deployed too far away to be able to communicate with CH. In such instance, a sub-cluster is made to include certain sensor nodes since it is probable that they contain important data that is of exceptional importance in a particular application, such as military surveillance, forest fire detection, etc. The creation of a sub-CH within each sub-cluster places it halfway between the sensor nodes of the cluster's members and the sensor nodes of the sub-cluster outside it.

3.3.1. CLSUTER FORMATION

Sectors are created once clusters and sub-clusters have been formed over the whole network region (containing number of cluster group inside them). Additionally, a mobile sensor node that serves as a mobile data collector is placed within each sector. Mobile data collector nodes will roam around each sector to gather information from multiple CHs (which combine information gathered from sensor nodes) and transmit that information to the BS. The combination of K-means and Expectation-Maximization (KEM) technique will be used as the foundation for the movement of mobile data collection sensor nodes.

This technique determines the energies and positions of each CH inside its own sector by computing them, and then comparing them after each round, starting with mobile data collection sensor nodes. Only the CH with the lowest energy is chosen from that group of CHs, and this is done using a mix of the K-means and the Expectation-Maximization (KEM) method. During that round, the mobile data collection sensor nodes are placed at the CH that is picked and has the least amount of energy. As a result, the mobile data collector sensor node will initially travel to the CH in its sector that has the lowest energy level, and it will collect data there. As it goes to each CH in its sector, it will then calculate the location of the next CH for its movement and data collecting.The BS receives the compiled information from the mobile data collector sensor nodes after collecting and aggregating the data from each and every CH, saving the energy of individual CHs for doing so.

To create a hybrid clustering method for improved clustering, the KEM technique combines the two clustering algorithms mentioned above. Utilizing the K-means technique, the first cluster centers are determined. These provide centers that are dispersed extensively across the data. These centers serve as the starting variables in EM, which iteratively searches for the nearby maxima. Consequently, K-means-based well-distributed clusters and EM-based compact clusters are generated.

The startup stage and the iteration stage make up the KEM algorithm's two (2) phases, much like the EM algorithm. The weighted average variant of the K-means algorithm, which performs higher in the selection of the starting centroids than the basic average variant, is used to categories the data into the appropriate number of clusters during the introduction step.

The following provides pseudocode for the KEM algorithm:

- Determine the cluster's k-value.
- Create k clusters at randomized, then identify their centers.
- Identify the closest cluster center for every location.
- Use weighted averages to calculate the new cluster centers.
- Create a basic model $M' = (C_1, C_2, \dots, C_k)$

repeat

- // (re-) Clusters are given points

Compute $P(x|C_i)$, and $P(C_i|x)$, for every x-th item from D and every cluster (= Gaussian) C_i

- // (re-) model computation

Create a new model $M = (C_1, C_2, \dots, C_k)$ by recalculatingW_i, μC and ∑C for each Cluster C_i

- Replace M' by M

until $|E(M) - E(M')| < \varepsilon$

- return M

In other words, the EM method begins with the assumption that these two sets of problems may be solved statistically in the following order: One may simply choose a random value for one of the sets of unknown values (means position and energy of chosen CHs), utilize those estimates to obtain a finer estimation for the second value, and repeat this process until the resultant numbers converged to the fixed points.Thus, CHs with little transmission energy may easily send data. Here, CH will only send consolidated data to a mobile data collection sensor node if it is within communication distance; else, it will wait. In MEACBM's steady-state phase, sensor nodes provide data to CH, MDC, and BS.In the designated TDMA frame, the detected data is transferred to CH. This data transfer occurs both inside the cluster and within the sub-cluster. Through the cluster member sensor node that is closest to the sub-cluster, the data gathered and summarized by the sub-CH in the sub cluster is sent to the CH of the main cluster. Then, all data from the sensor nodes that make up that cluster as well as data from the sub-CH are combined, gathered, and sent to the BS.The MEACBM Set-up phase was followed by a somewhat lengthier Set-up phase. Additionally, CSMA spreading code was supplied, which lessens the interference that develops within each cluster while data is being sent. This CSMA spreading algorithm is used by each sensor node to prevent inter-cluster disturbance during data transfer. After sending the first round's aggregated data to the BS, the CH must determine if it can continue serving as CH or whether a new CH has to be selected.In all situations, CH must inform the cluster member of its CH-ID. Up until all sensor nodes run out of energy, this setup and steady state phase procedure occurs. Therefore, motion enables CHs to send data while using the least amount of energy possible. The CHs must provide the data to the BS after collecting it from various clusters. As a result, the transmitting nodes are chosen depending on the nodes with the largest remaining energy. The data is chosen to be sent to the BS by the nodes with the greatest energy. It assists in reducing packet loss and increasing the packet distribution ratio.

3.4. ENERGY-EFFICIENT DATA ROUTING USING FUZZY SQUIRREL SEARCH ALGORITHM

The first stage of the suggested study methodology involves employing the Fuzzy Squirrel Search algorithm to perform energy usage conscious routing. For the best route path selection, this study effort takes into account the following Quality of Service (QoS) parameters: "Energy, Bandwidth, Computational power, and Consistency." It is a Non-Deterministic Polynomial (NP) issue to route WSNs depending on QoS.

The Squirrel Search Algorithm (SSA), a brand-new optimization approach that is biologically inspired, has been found to be more effective in addressing unimodal, multimodal, and multidimensional optimization difficulties. [Citation needed] [Citation needed] [Citation needed] [Citation needed] [C The Flightless Squirrel Sparrow is able to mimic the dynamic feeding behaviour of southern flying squirrels in the deciduous woodlands of Europe and Asia by employing glide, an efficient method utilized by tiny animals for long distance transport. When it's warm outside, squirrels move about the forest by gliding from one tree to another in search of food supplies.To satisfy their daily energy demands, they may readily obtain acorn nuts. Then they start looking for hickory nuts, which are kept for the winter and are the best food source. They are lesser active in the cold and continue to meet their energy needs by storing hickory nuts. Flying squirrel activity increases as the temperature rises. The aforementioned procedure is repeated and keeps on over the squirrels' whole life span, and it forms the basis of the FSS. The following mathematical steps may be used to simulate the optimization FSS in accordance with the flying squirrels' method of food gathering.

FSS routing provides a beginning path. Every node in the network generates and maintains a routing table for every other node to construct routes between source and destination nodes. When a source node has to transport a data packet to a destination node, it initiates an agent-based routing discovery procedure if the routing database is empty. The source node constructs a forward agent using routing discovery, recording its own address and data to give the agent a time, and then broadcasts the agent to each subsequent node. Forward agents advertise their messages during route discovery. Once the forward agent reaches the destination node, a path is defined. Forward agent will become reverse agent. Along the path broadcast by the forward agent, the reverse agent returns to the source node and adjusts the routing tables transmitted to other nodes based on the network status. Multi-agent based routing discovery is this strategy. Because forward agent routing uses broadcasting, many arrive at the target node. That is, there will be more paths between the source and destination nodes, which is the FSS algorithm's initial swarm.

The QoS routing paradigm uses FSS in addition to an agent-based approach.

Step 1: The forward agents and the reversed agents are applied after choosing a route set requires both the source node and the destination node in order to be created (swarm) among them.

Initialize the FSS

Produce the squirrel's location $X_i; i = 1,2, \ldots\ldots, SN$.

Choose half of the bees to be PSO-employed workers.

Step 2: To get Pi, determine the simulated QoS for each squirrel route and choose the best one $\theta_k(c)$ as Pi.

Analyze the population's efficiency (fake QoS for each route; fi = pi).

Step 3: To get a fresh routing route, use FSS iterations.

For each squirrel on acorn tree Do

create new synthetic QoS solutions V_i

Find the synthetic QoS rating f_i.

use a stingy hiring approach

Determine the pi-values for the options' probabilities X_i

Every squirrel on a typical tree

Choose a result X_i based on p_i.

Create a fresh remedyV_i

Parameters should be calculated using the greedy selection method.

A fresh, independently generated solution will be used to

replace any previously used ones for the hickory tree.

Keep in mind the finest answer thus far.

Step 4: When a path's QoS (squirrel) is superior to P_i, substitute it for Pi. the finest moment P_i is better than $\theta_k(c)$, Use it in lieu of P_i.

Step 5: The method terminates if the number of iterations exceeds the predetermined limit or the QoS computing value satisfies the specifications. If not, go to Step (3).

Step 6: Identify the route, then change the routing table.

cycle = cycle + 1

until cycle=MCN

4. Experimental Results

Through a MATLAB simulator comparison with various cluster-based routing protocols, the performance of MDSEASM-KEM is examined in this section. These effectiveness parameters include Network Lifetime, Stability Period, Number of CHs, Throughput, Number of Dead Nodes Per Round, Energy, Packet Loss, and Consistency.In the network area of 500 m by 500 m, we have considered 30, 50, and 100 regular sensor nodes with an initial energy of E0. Additionally, we have considered 45, 70, and 150 advance sensor nodes (m = 0.2 percent of normal sensor nodes) with an energy that is three times greater($\alpha = 3$)with 1.5 times more energy than standard sensor nodes, and 75, 125, and 250 intermediate sensor nodes (x = 0.3 percent of standard sensor nodes) ($\beta = 1.5$) than the corresponding conventional sensor nodes. These sensor nodes will all continue to function till their energy runs out.

A. Network Lifetime

It is calculated as the number of rounds completed up to the network's final dead node. The network's coverage region determines this. Because mobile movement paths, changeover times, and sojourn times all rise with increasing network area, the network's lifetime diminishes.

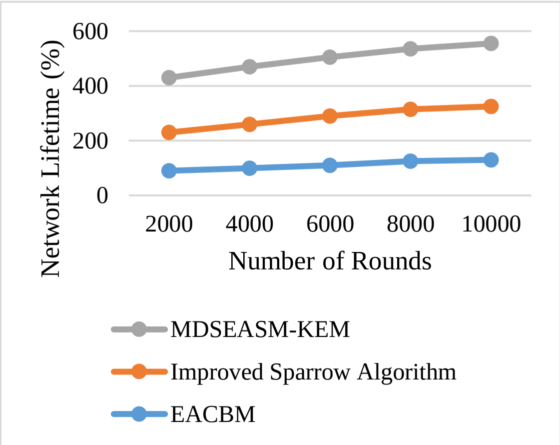

Fig 2: Network lifetime Comparison Graph

Figure 2 compares the network lifetimes of the known techniques, such as the EACBM approach and the Improved Sparrow Algorithm, with the new MDSEASM-KEM methodology. When compared to the current method, it is noticed that the suggested MEACBM-KEM algorithm achieves a greater network lifespan.

B. Stability Period

It is characterized by being equal to the aggregate number of rounds played before the first node dies. By regulating the energy usage, efficient grouping and mobile sink movement have greatly extended the network's period of stability. The amount of sink rounds performed without a dead node also indicates the stability of the network.

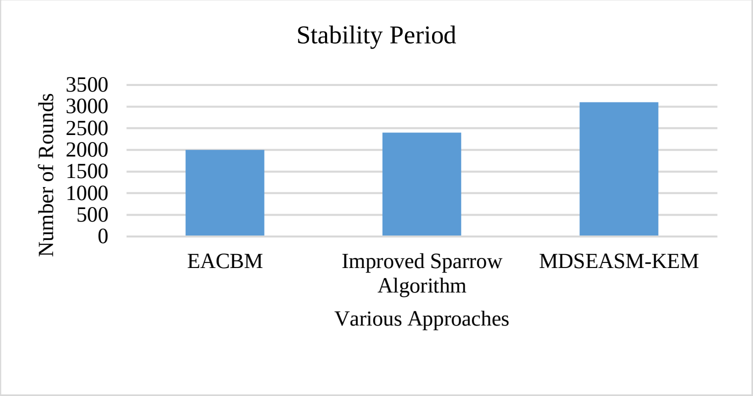

Fig 3: Stability Period Comparison Graph

Figure 3 compares the proposed MEACBM-KEM technique's stability period to those of current approaches like the Improved Sparrow Algorithm and the EACBM approach. It is noted that the proposed MEACBM-KEM algorithm attains better Stability Period when compared with the existing technique.

C. Numbers of CHs

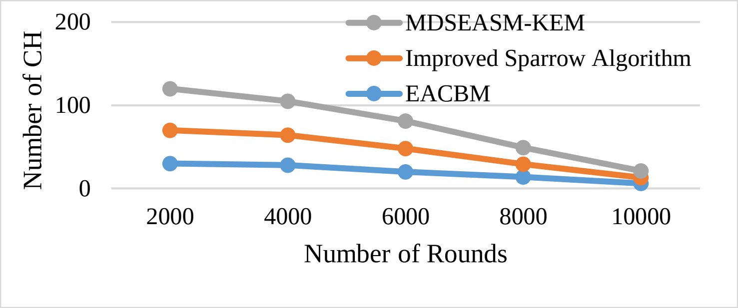

Fig 4: Number of CH's Comparison Graph

Figure 4 displays a comparison of the planned MEACBM-KEM method using the number of CH's and the existing approaches like Improved Sparrow Algorithm and EACBM approach. It is noted that the proposed MEACBM-KEM algorithm attains higher Number of CH's when compared with the existing technique.

D. Numbers of dead nodes per round

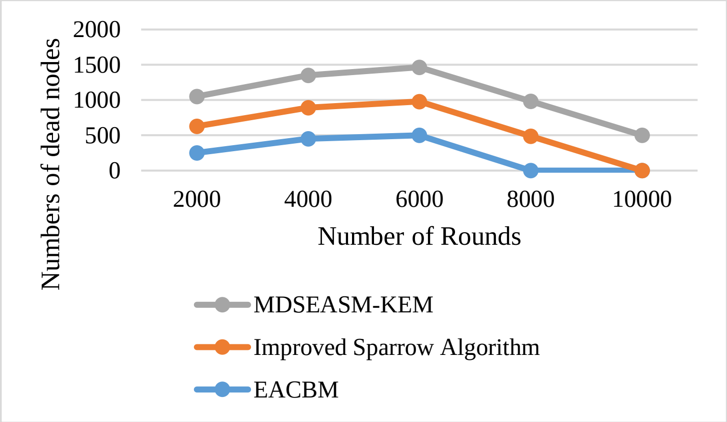

Fig 5: Number of dead nodes per round Comparison Graph

Figure 5 displays how many dead nodes there are per round comparison of the proposed MEACBM-KEM approach and the existing approaches like Improved Sparrow Algorithm and EACBM approach. It should be highlighted that the suggested MEACBM-KEM algorithm outperforms the currently used method.

E. Average Energy Consumption

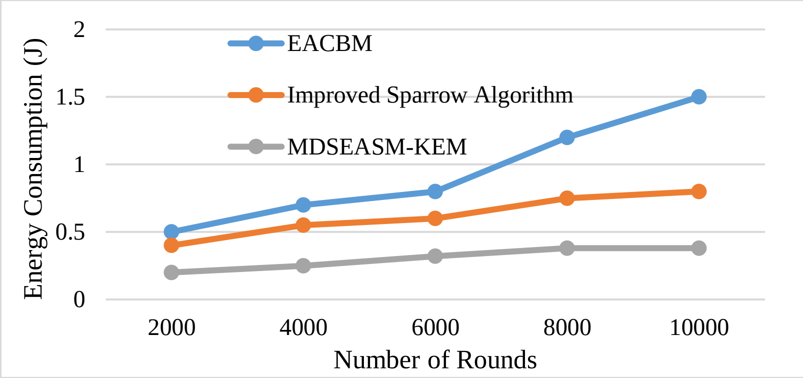

Fig 6: Energy Consumption Comparison Graph

Figure 6 compares the proposed MEACBM-KEM technique's energy consumption to that of already-in-use methods like the Enhanced Sparrow Algorithm and the EACBM method. It should be highlighted that the suggested MEACBM-KEM algorithm uses less energy than the current method.

F. Throughput

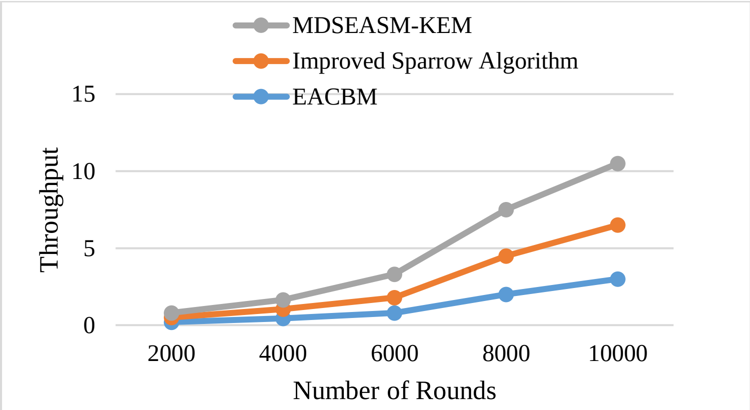

Fig 7: Throughput Comparison Graph

Figure 7 compares the proposed MEACBM-KEM technique's throughput to that of current approaches like the Improved Sparrow Algorithm and the EACBM approach. It should be highlighted that the suggested MEACBM-KEM algorithm outperforms the current method in terms of throughput.

5. Conclusion

Secured routing and data transmission serves an essential part in the functioning of the wireless sensor network which is achieved in this research work by utilizing the Modified Dolphin Search based Energy Aware Secured Multi-Hop Routing using hybrid of K-means and Expectation-Maximization Technique (MDSEASM-KEM) routing protocol. This proposed methodology reduces the computation overhead by clustering and choosing cluster head selection which is responsible for collecting and transmitting data packets. Overall energy consumption of the research work is improved by adapting the fuzzy squirrel search algorithm by using which optimal and energy consumption aware routing will be carried ours. By using the suggested technique in the NS2 simulation environment, the effectiveness of the approach is examined and compared to other approaches. From the analysis it is confirmed that in terms of energy consumption proposed methodology shows 67% performance improvement than the existing methodology.

In this research work, attack prevention only concentrated where in future attack detection can be included to ensure the most secured environment. Machine learning techniques can be integrated in the environment as monitoring nodes, so that entire data transmission flow can be monitored successfully.

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