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EFFICIENT DATA GATHERING MODEL WITH ENERGY BASED ROUTING FOR COMPRESSIVE SENSING IN MULTI-HOP HETEROGENEOUS WIRELESS SENSOR NETWORKS

BEJJAM KOMURAIAH [1,*] , DR.M.S. ANURADHA [2]

[1]Research Scholar, Department of ECE, AU College of Engineering (A), Visakhapatnam, AP, 530003, India

[2]Professor, Department of ECE, AU college of Engineering (A), Visakhapatnam, AP, 530003, India.

E-mail: [1]kvvkomraiah@gmail.com,

ABSTRACT

Lack of efficiency and infective routing are the major drawbacks in the compressive sensing based multi hope Heterogeneous Wireless Sensor Network (HWSN). To expand the longitivity and lifespan of the sensors it is very essential to concentrate on power utilization and routing models. For that purpose in this article Efficient Data Gathering Model with Energy based Routing is developed in compressive sensing based HWSN (EDGER-HWSN) network. The major categories of the proposed models are effective network model, radio and energy model, cluster formation algorithm, and inter cluster communication process. At the initial stage an effective network model is constructed which includes all the essential aspects of HWSN node construction with proper energy requirements. Followed by that a clustering process is performed that separates the normal sensors and the cluster heads (CH). The optimal CH is selected through this process and that's pointers to reduce the latency and energy consumption among the heterogeneous nodes. With the presence of these models the efficiency of the network is improvised by the proper utilization of power among the sensor nodes and at each data transmission routing is also effectively monitored and the parameters like link failures and data loss are detected and neglected. The implementation of this model is performed in Network Simulation 2 (NS2) and the parameters analysis is performed concerned with nodes and sensors speed. At the end of the simulation it is proven that when compared with the earlier baseline methodologies EDGER-HWSN model performed better results concerned with power utilization, efficiency and throughput which enhances the functionalities of compressive sensing based HWSN network.

Keywords: *Heterogeneous Wireless Sensor Network (HWSN), Compressive Sensing, Cluster Formation Algorithm and Inter Cluster Communication Process*

1. INTRODUCTION

HWSN network has now increasingly developed and it is used for various applications like target tracking, military applications and analyzing the environmental monitoring process for both remote and adverse conditions. Currently, these kinds of network working with limited energy in each node [1-2]. At the same time timely dissipation of the collector information of each sensor node receives some potential loss of the nodes at the time of external disaster in the network. Significant challenges which are present in the HWSN network are reducing power utilization and node failure and as well the improvement of routing models [3]. The functional structure of HWSN network is illustrated in the figure 1.

In recent days to balance the load in the HWSN compressive sensing models are concentrated which becomes a key technology for large scale HWSN network in the research field [4-6]. In heterogeneous network the transmission of data is the continuous process where it consumes more energy and that causes the nodes to die which leads to an ineffective network model and no replacement of nodes is possible at that condition and that increase is the utility of alternate battery source which makes the network not cost effective [7-8]. To overcome these kinds of drawbacks in the network in recent times cluster based approaches are concentrated which is suggested as the alternative model to escalate the scalability and lifespan of the HWSN [9].

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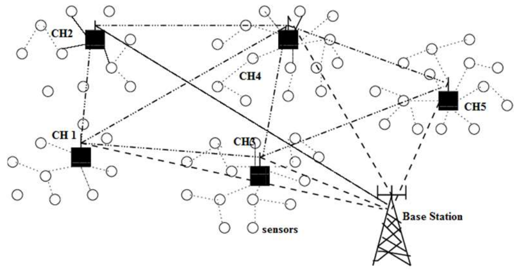

Figure 1: Functional Structure of HWSN Network

Various models are introduced in the classification of base network which consist of a similar process such as cluster head (CH) selection, cluster member analysis, [10-12] cluster formation, cluster maintenance and two communication model such as sensors based inter-cluster and intra-cluster communication and for certain level it reduces the power utilization of the heterogeneous sensors. But still it needs optimal improvement to handle large scale HWSN sensor nodes with high efficiency for that purpose in the article and novel method is proposed which consists of certain contributions.

1.1 Research Contribution

- Mainly to expand the sensor lifespan this proposed model is developed. The major four contributions of this model is effective network creation, cluster formation, inter-cluster communication and cluster maintenance.
- Here the optimal CH is selected with the presence of effective routing and intelligent energy consumption model which mainly helps to expand the sensor lifespan.
- As the whole this proposed model can able to maximize the HWSN efficiency and scalability.
- Organization of the paper is scheduled here were it consist of four main chapters which is the related works, proposed method elaboration, experimental demonstration and conclusion.

2. RELATED WORKS

In [13], the author Abel García-Nájera et al., concentrated on selecting efficient cluster heads for data collection and transmission, considering multiple objectives. The three evolutionary algorithms utilized for the study explores the trade-offs between these objectives and minimize power utilization in the network. In [14], the author Kalaivanan Karunanithy et al., developed the improved clustering to increase the WSN lifespan when combining with IoT. This protocol practices the fuzzy logic to choose the CHfor data collection. This protocol reduces power utilization than others

In [15], the author Mustapha Reda Senouci et al., introduced a probabilistic model for node connectivity, uses belief functions theory for evidence fusion, and employs genetic algorithms for deployment. The simulation results confirm its ability to meet the user performance needs showcasing the feasibility of deploying reliable WSNs with predictable performance in real-world settings. In [16-17], the author Fakhrosadat Fanian et al., introduced PS-SFLA, which provides effective clustering with multi-hop communication in WSN. This technique optimizes parameters for clustering and routing processes, to enhance the communication quality. In [18], the author Ramin Yarinezhad et al., presented an algorithm for load balanced clustering in WSN. This algorithm optimizes the energy consumption in finding effective route among the CH and BS.

In [19], the author Seedha Devi et al., proposed a novel approach to improve the WSN performance. This method consists of two phases: compressive aggregation at CHs and making an aggregation by the sink; then prioritizing node time slots considering packet loss rate and latency, thereby reducing retransmissions. This method addresses the energy balancing, packet loss, delay. In [20], the author Pawan Singh Mehra et al., presented an effective cluster based model. This algorithm uses Fuzzy Inference System considering node energy, distance from sink, and local node density for the process of cluster co-ordinators selection. This method provides data collection efficiency and high energy consumption. In [21], the author Kalaivanan Karunanithy et al., developed an efficient data collection model and it employs waiting time-based CH selection, considering residual energy, and efficiently utilizes Unmanned Aerial Vehicles (UAVs) for wide-area sensor data collection in agricultural fields. This helps to analyses the water and fertilizer provision in drip irrigation.

In [22-23], the author Raj Priyadarshini et al., developed a novel model to reduce the energy utilization in the WSN. It utilizes the AVL tree rotation and modified K-means clustering algorithms to lessen the computational complexity. In [24], the author Bandi Rambabu et al., presented a hybrid optimization model for effective clustering process which mainly used to maximize energy performance. In [25], the author Ankit Gambhira et al., developed a new protocol with improved

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optimization process and that is based on swarm intelligence cross various WSN scenarios. This method increase the energy management and routing efficiency.

In [26-27], the author Kale Navnath Dattatraya et al., proposed a hybrid optimization model which helps to improve the WSN communication quality. This method identifies the optimal CH and it increases the network efficiency. In [28], the author Bilal Saoud et al., proposed a protocol with firefly algorithm to optimize the CH selection. This method aimed to neglect the additional power utilization and increase the data success rate among the nodes. In [29], the author Tarek Azizia et al., proposed the newest data aggregation model, which integrates collection of data with TDMA protocol. This protocol focused on optimizing network performance by efficiently managing energy consumption, reducing redundant data transmission, and maximizing the utilization of available bandwidth.

In [30], the author Qiuling Tanga et al., introduced the EB-LEACH-MIMO scheme, combining the energy-balanced LEACH protocol with cooperative MIMO. This scheme's effectiveness in balancing network load, conserving energy, and maximize lifetime of sensors. In [31], Bhukya Suresh et al., introduced a Ranking process for clustering incorporating node coverage, power utilization rate, and distance to the BS. This result demonstrates significant improvements in energy efficiency, network longevity, and communication quality in WSNs due to this strategy. In [32], the author Amuthan et al., developed an intelligent CH election process, that integrates energy and trust assessment in predicting optimal cluster heads for sensor networks. This method significantly extends lifetime and decreases the power depletion by 28% and 34%, respectively.

With the above said references the present work is introduced to develop article Efficient Data Gathering Model with Energy based Routing

3. PROPOSED EDGER-HWSN APPROACH

HWSN Networks needs an effective improvement in terms of power utilization, for that in this proposed model initially an effective system model is constructed through suitable sensor deployment with radio and energy model. Secondly cluster formation algorithm is developed with effective optimal CH selection process this include a suitable power utilization model. Finally inter cluster communication is carried out which includes gateway node selection and parent node selection process. The proposed EDGER-HWSN structure is described in figure 2.

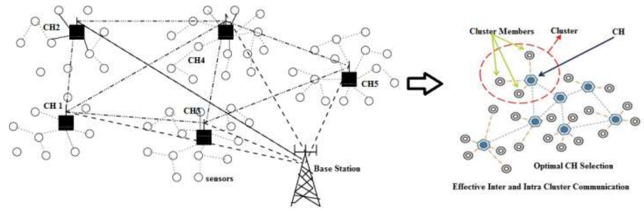

Figure 2: Proposed EDGER-HWSN Architecture

3.1 System model

This system defines the fundamentals requirements of the proposed EDGER-HWSN:

- The network consists of N distinct SNs; some of them are permanent, and others are in the form of moveable condition. The nodes with permanent locations are known as fixed Super Networks (SNs). Those permanent nodes are otherwise called as relay nodes. However, the other nodes are movable and it can only be used as cluster members and are allowed to travel within the deployed network.
- Battery-operated and including an interchangeable battery, sensor nodes are diverse in type.
- Without any energy constraints, base station (BS) is located in the center region which has to be examined.
- The CH election process involves static partial SNs.
- Every single SN has a distinct identification and is aware of its location.

It is thought that all SNs in their broadcast range can communicate with one another. Each sensor node, depending on the information it has detected, produces a binary value. The sensor protects its coverage area in the shape of a circle with a radius of R_s. The ideal node value is predicted only if those nodes are presents in that particular coverage area; if not, it signals 0. The distance between the mobile node and the stationary sensor node determines which nodes are the targets. This is what it may be described as

$$d = \begin{cases} 1, d \leq R_s \\ 0, d > R_s \end{cases} \qquad (1)$$

Where R_s denotes the SN's sensing radius and d denotes the target's distance from it. The GPS-based location estimate allows the statically positioned sensor stores its location details. To improve routing speed, each SN computes and accumulates the position data of its neighboring nodes at the beginning of the tracking period.

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3.2. Radio and Energy model

The suggested approach makes use of a radio model that calculates the crossover distance by measuring the shortest distance among the transmitter and receiver. The definition of transmission power is as follows:

$$p_{tr} = \frac{P_t G_t G_r \lambda^2}{(4\pi\lambda)^2} \quad (2)$$

In this case, P_t, G_t, and λ stand for the signal's wavelength, transmission power, and antenna gain. The transmission power is increased when the receiver's distance exceeds the crossover distance.

$$P_{tr} \frac{P_t G_t G_r h_t^2 h_r^2}{d^4} \quad (3)$$

The transmitter and receiving antenna heights are denoted by the symbols h_t and h_r, respectively. The energy model is mathematically expressed in equation (4) for m-bits of data with distance d.

$$\begin{Bmatrix} E_c(m,d) = m\left(E_{elect} + \varepsilon_{fs} d^2\right) & d < d_c \\ E_c(m,d) = m\left(E_{elect} + \varepsilon_{mp} d^4\right) & d \geq d_c \end{Bmatrix}, \quad (4)$$

where ε_{fs} and ε_{mp} implies the sender's sensitivity and the noise factor, and d_c implies crossover distance between the transmitter and receiver. E_{elect} implies electrical energy. The mathematically expression for the radio energy is given in equation (5).

$$E_c = mE_{elect} \quad (5)$$

3.3. Cluster Formation Model

To generate query target clusters, we first describe the cluster creation process in this section. Next, we calculate the optimal clusters using the following mathematical calculations.

3.3.1. Clustering Process

By using the geographical distribution of query targets as a basis, BS seeks to generate optimum clusters. We take into consideration the following three factors when creating the cluster creation algorithm: First and foremost, we anticipate that the clustering method will be able to analyses the node position dataset and generate clusters based on node locations with little computational overhead. We choose to use the K-Means technique for cluster construction in light of the aforementioned two constraints. The second step is to specify the anticipated cluster counts, k, earlier conducting the K-means model k_{opt}, which implies the cluster count, is determined using the math model to reduce power utilization in data retrieval process and it is constructed in the sub sequent section.

$$k_{opt} = \frac{M\beta}{d_{BS}^2}\sqrt{\frac{\alpha n\beta.\epsilon_{fs}}{6.\epsilon_{mp}}} \quad (6)$$

The parameters are as follows: M is the square observation area's length; αn is the amount of targets for inquiries in each round; β is the average number of hops required for transmitting the data from the CHs to the BS; and d_{BS}^2 implies the CH and headquarters average distance. Finally, in order to minimize intercommunication costs and preserve the power by using the load balance process among the sensors, we select the suitable sensor which remains closest to the cluster and whose residual power exceeds the average power of the sub-network sensors as the CH. Based on the examination of the aforementioned three factors, the process of ideal cluster generation in each operating cycle consists of the subsequent actions:

- Depending on where the query targets are located, a set of queries issued by end users are routed to appropriate sub-networks.
- After receiving queries in each sub-network, BS uses formula (6) to regulate the ideal cluster counts.
- The CH selection criteria are used by BS to choose the CH for each cluster.
- Each node in the local sub-network, BS broadcasts the data about ideal clusters.

3.3.2. Optimal Cluster Selection Process

The best clusters which are present in each sub-network is found by building an analytical model, which is implemented at the BS. Assuming that the pro portion of query targets is α and that n nodes is equally dispersed in the M × M area. Each cluster has an average of αn nodes if the cluster count is k. Each cluster occupies an area of around M2/k. We assume that each cluster's coverage area is a square place with L×L dimensions, and we represent this square place's circumradius with R. Hence, L = √ 2R is the relationship between L and R. One way to express the anticipated squared distance between nodes and the CH is:

$$E[d_{CH}^2] = \int_0^{\sqrt{2R}} \int_0^{\sqrt{2R}} \rho[(x - \frac{\sqrt{2R}}{2})^2 + \left(y - \frac{\sqrt{2R}}{2})^2\right] dxdy,$$

$$= \int_{\frac{-\sqrt{2R}}{2}}^{\frac{\sqrt{2R}}{2}} \int_{\frac{-\sqrt{2R}}{2}}^{\frac{\sqrt{2R}}{2}} \rho(u^2 + v^2) dudv,$$

$$= \rho \frac{2R^4}{3} \quad (7)$$

The density of nodes is $\rho = k/M^2$, then we can get:

$$E[d_{CH}^2] = \frac{k}{M^2} \frac{2R^4}{3} = \frac{M^2}{6k}. \quad (8)$$

To account for the power utilization of sensors in our analytical model, we employ a first-order radio energy model. As a result, the energy used by a sensor node to send a message (l bit) to a node that is dm distant may be expressed as

$$E_{TX}(l,d) = \begin{cases} E_{elec}l + \epsilon_{fs}ld^2, d < d_0. \\ E_{elec}l + \epsilon_{mp}ld^2, \ d \geq d_0. \end{cases} \quad (9)$$

In this case, the energy cost per bit for either the transmitter or the receiver is represented by E_{elec}, and the transmission amplifier parameters that match the free-space and multi-path fading models are indicated by ϵ_{mp} and ϵ_{fs}, correspondingly. The distance between the transmitter and the recipient is represented by d, while the threshold transmission distance is indicated by. $d_0 = \sqrt{\epsilon_{fs}/\epsilon_{mp}}$ It is possible to define the energy used by a receiver to retrieve a l-bit message as

$$E_{RX}(I) = E_{elec}l. \quad (10)$$

It is necessary for all nodes to hear the cluster and inter-cluster route broadcasts from the base station during the sensor data retrieval phase. The transmitted information by the cluster members (CM) is received by the CH in the local sub-network. Given that the CH and the CMs are present in the same cluster which is physically close to one another, the power utilization for the CMs transporting data to the CH are mathematically expressed in equation (11):

$$E_{member} = E_{elec}l_{brd} + E_{elec}l + \epsilon_{fs}ld_{CH}^2,$$

$$= E_{elec}l_{brd} + E_{elec}l + \epsilon_{fs}l\frac{M^2}{6k}. \quad (11)$$

A significant amount of energy is used by CH in the processes of gathering data from CMs and transmitting it to BS. Sensor data from the CHs is sent to the BS in one or two hops using the inter-cluster routing technique. The estimated value of β for a given scenario may be established through simulation. We assume that the data were relayed an average of β (1 < β < 2) times prior to arriving at the BS. Furthermore, in inter cluster communication, each relay's distance is very long; as a result, the power utilization is in line with the multi-path fading model (d > d0) as illustrated in the equation (9).

$$E_{inter-clust} = \beta[E_{elec}l.\left(\frac{\alpha n}{k} - 1\right)E_{DA}l\frac{\alpha n}{k} + E_{elec}l + \epsilon_{mp}l\left(\frac{d_{BS}}{\beta}\right)] \quad (12)$$

Where d_{BS} is a representation as average distance among CHs and the BS and the approximate value of d_{BS} may be found by the BS using the query targets. The energy usage for data aggregation is represented by E_{DA}. After accounting for the energy used for both intra and inter cluster data transmission, the total energy used in a single round is

$$E_{total} = kE_{cluster},$$

$$= kE_{inter-clust} + k\left(\frac{\propto n}{k} - 1\right)E_{intra-cluste},$$

$$\approx kE_{inter-cluste} + \propto nE_{member},$$

$$\approx \beta[E_{elec}l(\alpha n - k) + E_{DA}\alpha nl + kE_{elec}l + \frac{\epsilon_{mp}ld_{BS}^4k}{\beta^4} + +\alpha n\left[E_{elelc}l_{brd} + E_{elec}l + \epsilon_{fs}l\frac{lM^2}{6k^2}\right] \quad (13)$$

The ideal number of clusters, K_{opt}, for each round is determined by

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$$K_{opt} = \frac{M\beta}{d_{BS}^2}\sqrt{\frac{\alpha n\beta.\epsilon_{fs}}{6.\epsilon_{mp}}}. \quad (14)$$

3.4. Efficient Communication inside Clusters

3.4.1. Gateway Selection Process

The position data is first transmitted by the BS to its neighbors within a two-hop radius. The intermediate node that sits among the CHs of layer 1 and the BS of layer 0 receives this message and uses Equation (20) represents the weight value (Twi(n)) calculation process, accounting for distance, residual energy, and available buffer memory. The registration message, which includes various combinations of weight values between the CHs or CH and BS, location, residual energy level, and available buffer memory, is only sent by these intermediary nodes to the concerned CHs of the bottom layer. The lowest layer CH grants permission to function as a gateway node after choosing the node with the highest weight among the registrants. Next, up to a maximum transmission range of 2Tr, the CH nodes of layer 1 broadcast to their neighbors their position, memory, and residual energy level. Until every CH is connected in the tree topology, the operation is repeated. According to Equation. (15) – (19), the weight values dw1 and dw2 are utilized to determine the shortest path between the CHs and BS, dw3 to choose the greatest residual energy node, and dw4 to choose the largest available memory node.

$$d_{w1} = \frac{d_{CB_i} - d_{CB_j}}{d_{CB_i}} \quad (15)$$

When CH node i and BS and CH node jand BS are separated by d_{CB_i}andd$_{CB_j}$, respectively. If the GN is located between the CHs, the GN uses Equation. (16) to determine the dw2.

$$d_{w2} = \frac{2T_r - (d_{CG_i} + d_{CG_j})}{2T_r - d_{c_{i,j}}} \quad (16)$$

(or) If the GN is located between the CH and BS, it uses Equation. (17) to compute the dw2.

$$d_{w2} = \frac{2T_r - (d_{CG_i} + d_{GB})}{2T_r - d_{CB_j}} \quad (17)$$

Tr represents the maximum transmission range, $d_{CG_i}$and d_{CG_j}indicate the separation between CHi and GN, dCi j indicates the separation between CHi and CHj, and dGB indicates the separation between GN and BS. Equation (18), when applied to the leftover energy, yields the weight value dw3.

$$d_{w3} = \frac{E_c}{E_{Nm}} \quad (18)$$

Equation (19) is utilized to get the weight value dw4 of the memory that is accessible.

$$d_{w4} = \frac{B_a}{B_m} \quad (19)$$

where B_a denotes the buffer's size that is accessible and B_m denotes its maximum storage capacity.

$$T_{wi}(n) = d_{w1} \times d_{w2} \times d_{w3} \times d_{w4} \quad (20)$$

3.4.2. Parent node selection

The data transmission is started by the tree's farthest child node, which chooses the parent node depending on factors including distance to the BS, buffer memory capacity, and residual power. The parent node is located by the GN or CH using Equation (23). Finally, it selects the node with the greatest weight value to serve as a PN after figuring out the shortest route to the base station (BS). This node has less work to do than other neighbor CHs or GNs. According to Equation (21) PN is chosen from GN to CH.

$$d_{w5} = \frac{d_{GB} - d_{CB_j}}{T_r} \quad (21)$$

(or) Using Equation (22), PN is chosen from CH to GN.

$$d_{w5} = \frac{d_{CB_j} - d_{GB}}{T_r} \quad (22)$$

where BS and GN are separated by a distance, d(GB).

$$T_{wp}(n) = d_{w3} \times d_{w4} \times d_{w5} \quad (23)$$

Once the CHs have established a tree topology using GN, they use a Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) technique to seamlessly send their aggregated data packets to the BS. Moreover, a fault tolerance mechanism may be effectively used in the proposed tree topology by confirming the connection between the nodes with little control

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overhead, which facilitates the identification of defective and link failure nodes. In the tree topology, the upper-level node (GN or CH) will not acknowledge the lower-level node (CH or GN) during the inter-cluster communication timeout. This is caused by a hardware failure or low power on the node. Consequently, the following methods are used by the lower-level node to find the new PN: (i) It finds a new GN by sending the route initiation message towards BS in the case that the connection from CH to GN fails; (ii) When a connection between GN and CH fails, GN finds a new CH by sending the PN registration message.

4. SIMULATION ENVIRONMENT

4.1 Number of Node Analysis

Here the proposed EDGER-HWSN implementation results are demonstrated and as well it gets compared with the earlier models CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN. The implementation is carried out in NS2 which is open source simulator with C++ and object tool command language (OTCL). The OS most suitable for networking simulation is Ubuntu OS and the network is constructed and to analysis the performance some of the parameters are measured they are malicious detection ratio, communication cost, data success ratio, data loss ratio, end to end delay, overhead packets, throughput and energy efficiency.

A. Malicious Detection Ratio:

It refers to the proportion or percentage of malicious nodes correctly identified out of the total number of actual malicious instances present in a given context. The graphical description of malicious detection ratio in Figure 3 illustrates how the Proposed EDGER-HWSNs provides higher detection ratio when compared to the existing techniques. This performance is attained with the presence of effective cluster selection process among the sensors which are highly involved in the process of communication among the devices. The sensors which are involved in malfunctions are detection and neglected from the data transfer and that results in the increase of communication quality among the devices.

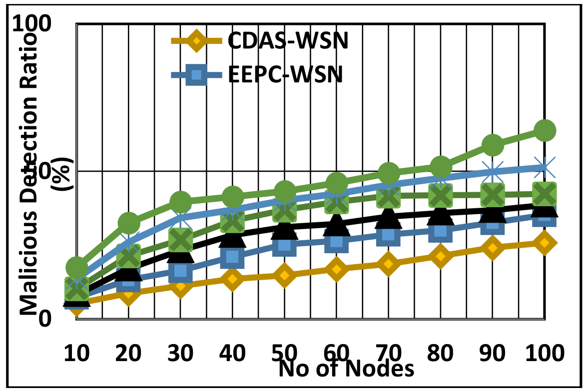

Figure 3: Malicious Detection Ratio

B. Communication cost:

It refers to the resources, in terms of time, energy, bandwidth, or other related factors, expended during the process of transmitting data between different nodes within a network. The graphical description of computational cost in Figure 4 illustrates how the Proposed EDGER-HWSNs provides lower routing cost when compared to the existing techniques. The clusters are selected in the proposed model in an optimal manner that greatly reduces the communication cost among the sensors at the time of data transmission. The minimization of communication cost leads to minimize the delay occurrences during communication.

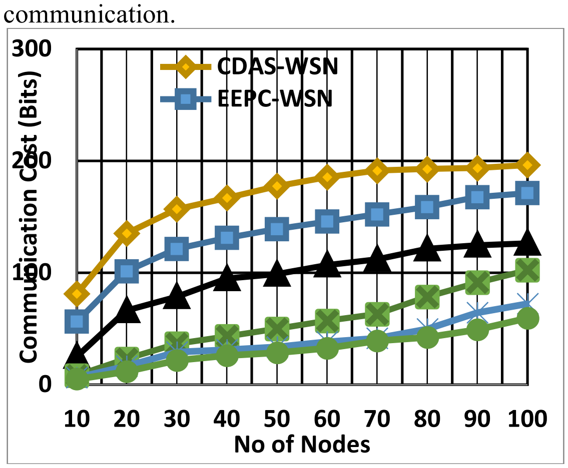

Figure 4: Communication cost

C. Data success ratio:

Success data of the transmitted data is measured by analysis the number data packets which gets transmitted to the destination successfully once after gets transmitted from the destination. In figure 5 success ratio performances of EDGER-HWSNs and other techniques are given.

In the proposed EDGER-HWSNs, inter-cluster communication is carried out in an intelligent ways with the combination of gateway selection and parent cluster node selection. Through this process each transmission among the sensors

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are effectively monitored and that leads to improve the data success ratio of the EDGER-HWSNs when compared with others.

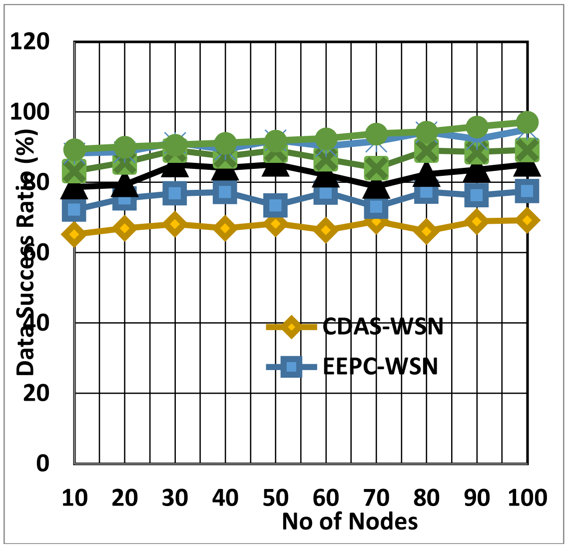

Figure : Data Success Ratio

D. Data loss Ratio:

It is the measure of the counts of information which get lost at the time of data transmission among the source and the destination. In figure 6 the measure of data loss of the EDGER-HWSNs model and others are given. Through the optimal CH selection in the proposed model each sensors transmits the data in a predefined pathway which minimizes the loss of data and data forwarding ratio. As the results of data loss reduction the quality of service of heterogeneous WSN network is improvised.

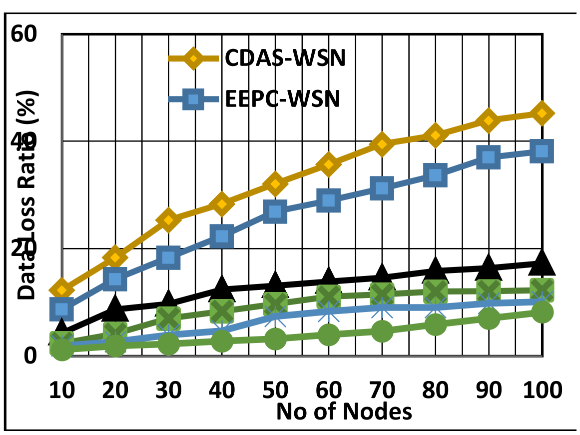

Figure 6: Data Loss Ratio

E. End to End Delay (ms):

In general there is a predefined time period is required for all the data transmission among the devices. Once after initiating the data transmission the time periods are measured for each iterations among the sensors. If that calculated time period exceeds the predefined time slot then the time difference if called as delay. For any kinds of network it becomes very essential to reduce the delay to attain maximum efficiency. In figure 7 the delay performance of proposed EDGER-HWSNs with other methods are shown.

The network and radio model of the proposed EDGER-HWSNs is design in the way to mainly decrease the network delay occurrences at the time of information among the devices. The elected CH is optimal to reduce the routing overhead so that the data forwarding ratio is reduced and that leads to the decrease of delay of the EDGER-HWSNs than the earlier baseline methods.

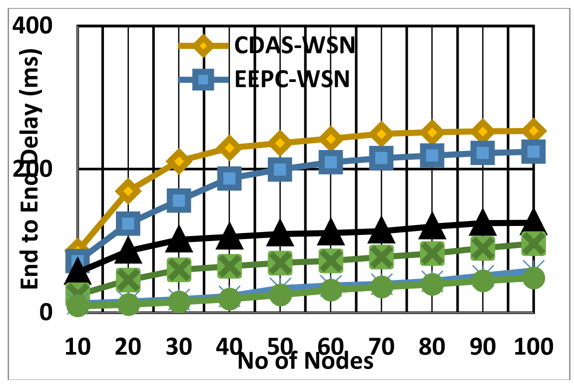

Figure 7: End to End Delay

F. Routing Overhead (packets):

At the time of data transmission in case if the link exceeds its threshold level then the data will get retransmitted to the source without reaching its destination and that increases the data forwarding ratio and it is otherwise called as routing overhead. In figure 8 the overhead performance is calculated for the proposed EDGER-HWSNs model.

The proposed EDGER-HWSNs is the combination of optimal CH election and effective inter cluster communication. The transmission among the devices at any millisecond is monitored periodically so that it neglects the reason for the occurrences of data forwarding at any time period which results in the reduction of routing overhead among the devices and that can able to increase of the overall performance and lifetime of the sensors.

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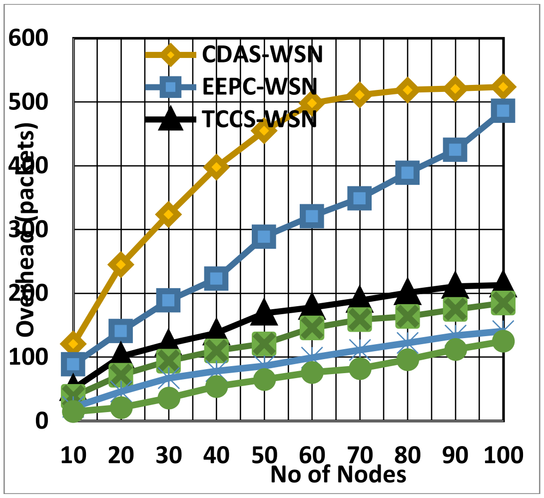

Figure 8: Routing Overhead

G. Throughput:

It is the measure of data which gets generated in the source at each time period. In generation reduction of data forwarding ratio increase the throughput level and that helps to improve the overall performance of the network. In figure 9 the throughput performance is analysis.

The optimal CH selection process reduces the power utilization and routing overhead of the sensors in the HWSN network and that allows large quantity of data to communication among the devices in an effective manner. So the generated throughput level of the EDGER-HWSNs comparatively higher than the earlier baseline methods.

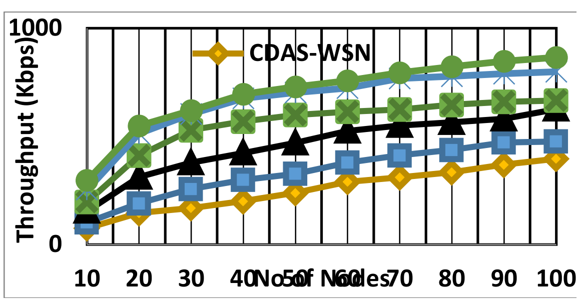

Figure 9: Throughput

H. Energy efficiency:

The energy which gets remained at the end of the simulation is the residual energy of the sensors and it is otherwise called as the energy efficiency of the sensors. For any network energy limitations are the primary drawback. So it becomes very essential to increase the efficiency of the sensors to attain maximum lifespan. In figure 10 the efficiency of the proposed EDGER-HWSNs is calculated.

Mainly clustering models are developed to expand the efficiency of the sensors and in EDGER-HWSNs also the similar idea is concentrated. With the presence of optimal CH selection process and maintenance model the efficiency of EDGER-HWSNs is improved and it is much higher than the earlier baseline methods.

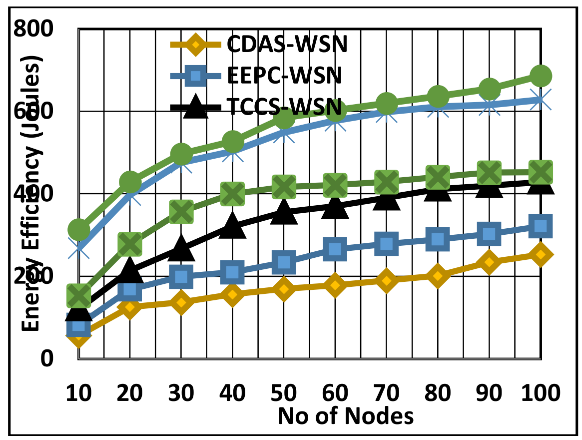

Figure 10: Energy Efficiency

4.2 Results of number of nodes

This section examines the measurements of earlier methods and Proposed EDGER-HWSNs strategy with regard to malicious detection ratio, communication cost, data success ratio, data loss ratio, end to end delay, overhead packets, throughput and energy efficiency. The metrics for those methods are shown in Table 2.

Table 2: Results Analysis and Measurements

Parameters / Methods	CDAS-WSN	EEPC-WSN	TCCS-WSN	MTODS-WSN	LPICR-WSN	Proposed EDGER-HWSNs
Malicious Detection Ratio (%)	25.79	35.26	38.59	42.36	51.33	63.83
Communication Cost (bits)	196.25	171.28	126.23	102.28	72.31	59.43
Data success ratio (%)	69.23	77.56	85.17	89.23	95.11	97.18
Data loss ratio (%)	45.23	38.16	17.28	12.28	10.11	8.17
End to End Delay	253.28	224.23	125.46	96.28	58.33	48.49

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(ms)						
Overhead (Packets)	524	486	213	185	141	125
Throughput (kbps)	396.28	476.23	625.39	665.37	798.33	865.17
Energy Efficiency (joules)	253.25	321.45	428.23	452.17	628.34	686.17

Initially, considering malicious detection ratio, the proposed EDGER-HWSNs method achieved highest detection rate of 63.83%. However the existing techniques, of CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN achieved 25.79, 35.26, 38.59, 42.36, and 51.33 respectively. Hence the proposed EDGER-HWSNs detect the malicious nodes of 38.04, 28.57, 25.24, 21.47 and 12.5% more than the existing methods. Then, in terms of communication cost, the existing method attains 196.25 bits, 171.28 bits, 126.23 bits, 102.28 bits, and 72.31 bits of CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN respectively, whereas the proposed EDGER-HWSNs method attains communication cost of 59.43 bits. This proves that the proposed EDGER-HWSNs model provides low communication cost when compared to the other existing methods.

We cannot get accurate data if the packet delivery ratio is too low. The approach of fusing sensor data overcomes the inadequacy of information. A high packet delivery ratio is also necessary for the tracking system to attain good performance. The According to the experimental findings, the suggested EDGER-HWSNs has a higher data success ratio than other methods. The proposed method exhibits 97.18% whereas CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN achieved 69.23%, 77.56%, 85.17%, 89.23% and 95.11% respectively. A frequent issue in WSN is packet loss and packet dropping, which reduces the ratio of delivered packets to delivered packets. Signal degradation in the medium as a result of multipath dropping might be the reason. The proposed EDGER-HWSNs method achieved minimum loss ratio of 8.17% but the existing technique has 45.23%, 38.16%, 17.28%, 12.28% and 10.11% of CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN. This shows the superior data integrity during transmission

The relay nodes, which send data to the BS, are operating without issue. But sometimes the number of mobile nodes within a certain radio range may grow, which causes an increase in data transmission within that range. There is an enormous quantity of data overloading the CH and static nodes. Here the proposed EDGER-HWSNs method operated efficiently and reached 125 packets which is lower when compared to the other techniques CDAS-WSN is 524 pkts, EEPC-WSN is 486 pkts, TCCS-WSN is 213pkts, MTODS-WSN is 185 pkts, and LPICR-WSN is 141 pkts. It is possible for the mobile sensors to link with another range after leaving the radio range. One CH forwards some of the data, while another CH forwards other partial data to BS. Hence the throughput is very important parameter. In the last simulation, the proposed EDGER-HWSNs has 865.17kbps which reached the highest value and the existing methods CDAS-WSN is 396.28kbps, EEPC-WSN is 476.23 kbps, TCCS-WSN is 625.39 kbps, MTODS-WSN is 665.37 kbps, and LPICR-WSN is 798.33 kbps.

The energy efficiency of the proposed EDGER-HWSNs is 686.17J at the end of simulation. However, it has been observed that CDAS-WSN is consumed 253.25J, EEPC-WSN consumed 321.45J, TCCS-WSN consumed 428.23J, MTODS-WSN is 452.17J, and LPICR-WSN is 798.33 kbps. The proposed EEPC algorithm consumed 22%, 10%, and 7% less total energy compared to TLCR, ECS-PSO consumed 628.34J, respectively. Limited battery capacity is the biggest challenge of the WSN environment, and the proposed EDGER-HWSNs consume very less energy and increases the lifetime of sensors as well.

4.3 Speed based Analysis

The subsequent section analyses and contrasts the suggested EDGER-HWSN simulation result estimation technique with established methods such as CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN. The Malicious Detection Ratio, Communication Cost, Data success ratio, Data loss ratio, End to End Delay, Overhead Packets, Throughput and Energy Efficiency.

A. Malicious Detection Ratio:

The figure 11 displays the graphical representation of the ratio of malicious detection. Initially, the ability to detect malicious activities within the network was observed to be highest in the "Proposed EDGER-HWSNs" method, showcasing a detection ratio of 83.71%. This surpassed all other methods CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN achieved 23.56%, 31.25%, 45.23%, 51.47% and 78.35%, signifying its superior capability in identifying and mitigating malicious intrusions. The detection rate of the proposed model is 5% to 10%

higher and it is attained by the presence of optimal CH selection and cluster maintenance of the proposed EDGER-HWSNs.

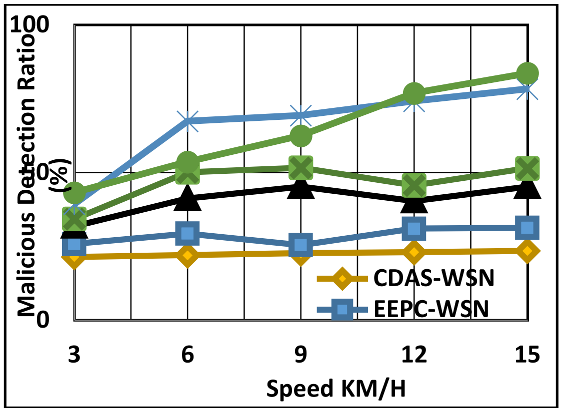

Figure 11: Malicious Detection Ratio

B. Communication cost:

The graphical description of computational cost in Figure 12. The "Proposed EDGER-HWSNs" method exhibited the lowest communication cost at 109.25 bits, outperforming other methods in terms of efficiency in transmitting information within the network whereas the existing method attains 247.23 bits, 221.36 bits, 126.23 bits, 156.38 bits, 132.17 bits and 123.45 bits of CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN respectively, whereas the proposed EDGER-HWSNs method attains communication cost of 59.43 bits. This proves that the proposed EDGER-HWSNs model provides low communication cost when compared to the other existing methods and it is attained using the effective CH selection and suitable network model among the devices in the network.

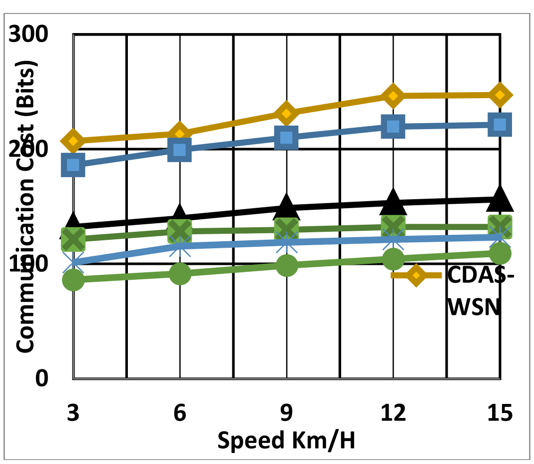

Figure 12: Communication cost

C. Data success ratio:

The Figure 13 suggests the graphical representation of the data success ratio calculation. Due to the Multi-hop Heterogeneous WSN, the suggested EDGER-HWSNs have a higher data success ratio than other methods. The proposed method exhibits 95.75% whereas CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN achieved 69.23%, 73.28%, 78.46%, 85.27% and 92.31% respectively. The success rate attained by the proposed model is around 5% to 16% higher than the earlier baseline methods and it is obtained with the utilization of effective parent and gateway selection process among the heterogeneous sensors.

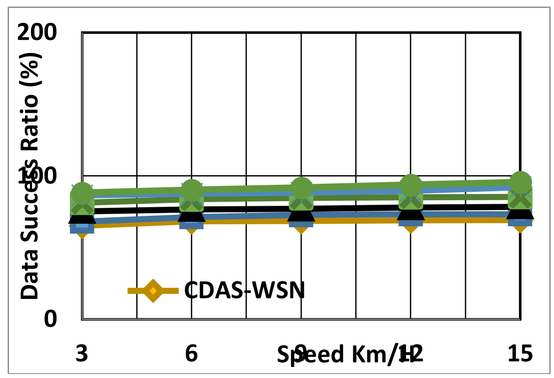

Figure 13: Data success ratio

D. Data loss Ratio:

Figure 14 suggests the graphical representation of the data failure ratio calculation. The Optimized CH selection process reduced the data loss ratio, the proposed EDGER-HWSNs method achieved minimum loss ratio of 11.74% but the existing technique has 29.36%, 25.17%, 19.24%, 15.27% and 13.68% of CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN. The data loss calculation proves that the proposed model produce loss which is around 3% to 19% lower than the earlier baseline methods. Such kind of CH selection process is utilized in the proposed EDGER-HWSNs.

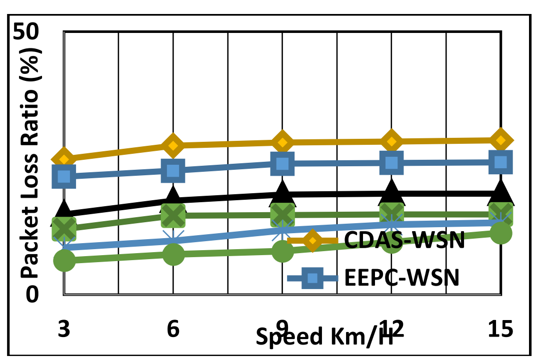

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Figure 14: Data loss Ratio

E. End to End Delay (ms):

Figure 15 shows the end-to-end delay calculations for the techniques. The presence of Inter cluster communication helps the proposed EDGER-HWSNs method achieved minimum delay 85.96 ms but the existing technique has 253.14ms, 221.46ms, 146.35ms, 124.39ms, and 96.87ms of CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN. This shows the superior data transmission. The inter cluster communication process which is present in the proposed EDGER-HWSNs is the combination of effective parent node selection for each transmission and as well intelligent gateway selection for every devices. With the utilization of these method this proposed model produced end to end delay which is around 15ms to 150ms lower when compared with the earlier models.

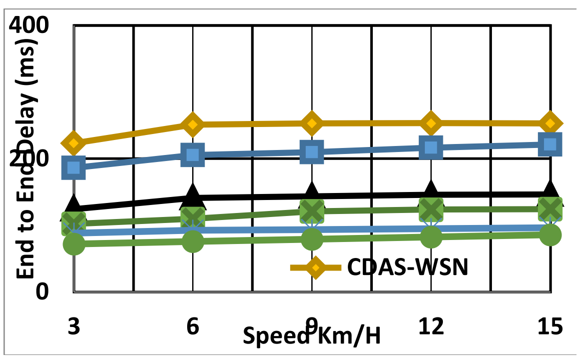

Figure 15: End to End Delay (ms)

F. Routing Overhead (packets):

The process entails calculating the total number of data packets generated by the source and the cumulative number of data packets sent to all nodes. When compared to existing methods like CDAS-WSN, EEPC-WSN, TCCS-WSN, MTODS-WSN, and LPICR-WSN, the Proposed EDGER-HWSNs provided reduced routing overhead, as shown by Figure 16 graphical explanation of routing overhead calculation. The relay nodes, which send data to the BS, are operating without issue. But sometimes the number of mobile nodes within a certain radio range may grow, which causes an increase in data transmission within that range. Here the proposed EDGER-HWSNs method operated efficiently and reached 169 packets which is minimum when compared to the other techniques CDAS-WSN is 435 pkts, EEPC-WSN is 386 pkts, TCCS-WSN is 246 pkts, MTODS-WSN is 224 pkts, and LPICR-WSN is 199 pkts

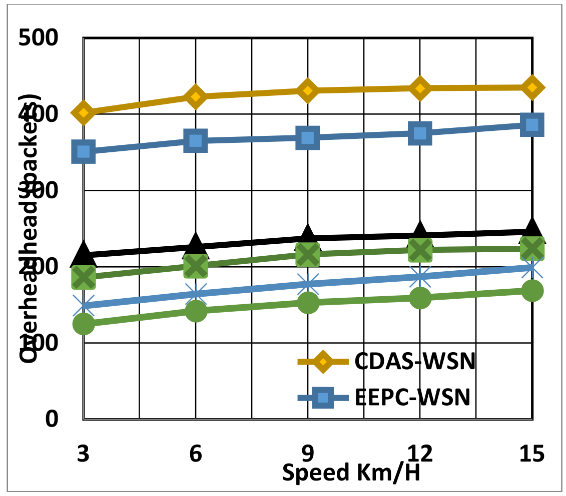

Figure 16 : Routing Overhead (packets)

G. Throughput:

The estimated graphical throughput representation in Figure 17. In the last simulation, the proposed EDGER-HWSNs has 915.17kbps which reached the highest value using the Efficient Data Gathering Model and the existing methods CDAS-WSN is 452.23kbps, EEPC-WSN is 521.36kbps, TCCS-WSN is 685.23 kbps, MTODS-WSN is 702.14 kbps, and LPICR-WSN is 834.12 kbps. The communication is predefined in the proposed HWSN network so that the number transmitted data is high for the proposed model sensors when compared with the earlier methods and that increases the throughput rate of the sensors which are present in the proposed network model.

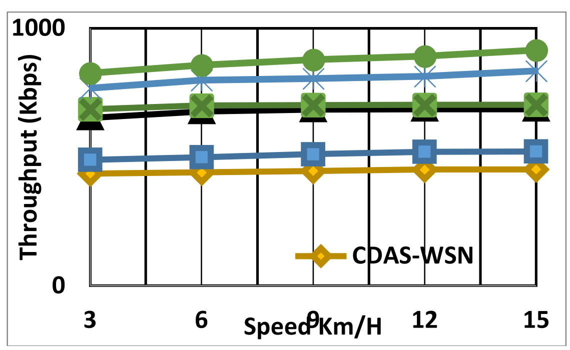

Figure 17: Throughput

H. Energy efficiency:

Figure which implied graphical display of energy efficiency computation. The energy efficiency of the proposed EDGER-HWSNs is 450.25J at the end of simulation. However, it has been observed that CDAS-WSN is consumed 247.23J, EEPC-WSN consumed 221.36J, TCCS-WSN consumed 156.38J, MTODS-WSN is 132.17J, and LPICR-WSN is 123.45J. Hence the proposed EDGER-HWSNs consume very less

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energy and increases the lifetime of sensors as well. The main concentration of this proposed EDGER-HWSNs is to increase the energy efficiency of the proposed sensors and that will increase the lifetime of the HWSN network. For that purpose the clustering model is improved in this proposed approach and the obtained results proves that the proposed EDGER-HWSNs attained efficiency which is around 200J higher than the earlier baseline methods.

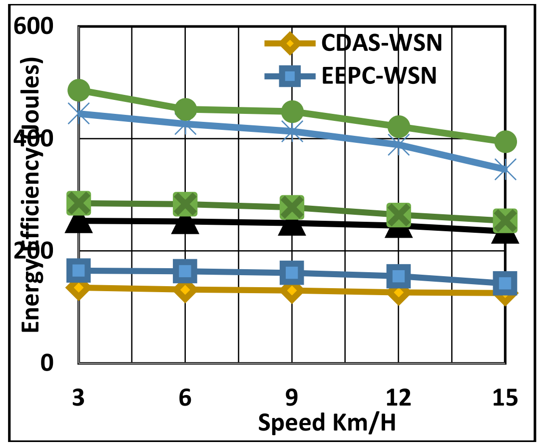

Figure 18: Energy Efficiency

The overall performance analysis of the proposed EDGER-HWSNs with the baseline methods in terms of speed variation is given in Table 3 below.

Table 3: Results Analysis and Measurements

Parameters / Methods	CDAS-WSN	EEPC-WSN	TCCS-WSN	MTODS-WSN	LPICR-WSN	Proposed EDGER-HWSNs
Malicious Detection Ratio (%)	23.56	31.25	45.23	51.47	78.35	83.71
Communication Cost (bits)	247.23	221.36	156.38	132.17	123.45	109.25
Data success ratio (%)	69.23	73.28	78.46	85.27	92.31	95.75
Data loss ratio (%)	29.36	25.17	19.24	15.27	13.68	11.74
End to End Delay (ms)	253.14	221.46	146.35	124.39	96.87	85.96
Overhead (Packets)	435	386	246	224	199	169
Throughput (kbps)	452.23	521.36	685.23	702.14	834.12	915.17
Energy Efficiency (%)	247.23	221.36	156.38	132.17	123.45	109.25

From this overall performance analysis is it proven that the performance of the EDGER-HWSNs is maximum in all the aspects when compared with the earlier baseline methods and it becomes possible with the presence of the effective CH selection, gateway selection and parent node selection process in required time period at the time of data transmission. Overall and intelligent network model is created which can able to obtain better performance in HWSN network model.

5. CONCLUSION

This proposed model is mainly designed to improve the energy efficiency and routing process which happens in the compressive sensing based multi-hop heterogeneous WSN network. The major models which are concentrated to improve the communication standard are effective system analysis which includes the network, radio and energy model of the system. And the steps of clustering are effectively analyzed in each module of the communication process. As the result the overall performance of the network is comparatively high with the earlier baseline methodologies in terms of power utilization, efficiency and throughput.

The performance analysis of the proposed EDGER-HWSNs is calculated in terms of number of devices and speed were the parameters which are considered to measure the performance are

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malicious detection ratio, communication cost, data success ratio, data loss ratio, end to end delay, overhead packets, throughput and energy efficiency. Concerned with number of devices the performance of the proposed EDGER-HWSNs the Malicious node detection rate is 12% to 35% higher, communication cost is 15bits to 140bits lower, data success rate is 3% to 28% higher, data loss ratio is 2% to 38% lower, end to end delay is 10ms to 200ms lower, routing overhead is 20packets to 300 packets lower, throughput is 80 kbps to 450 kbps higher, and energy efficiency is 60 joules to 400 joules higher when compared with the earlier baseline methods.

Concerned with the speed of the vehicles the performance of the proposed EDGER-HWSNs, The malicious detection ratio is 5% to 40% higher, communication cost calculation is 14bits to 135bits lower, data success rate is 3% to 24% higher, data loss rate is 2% to 18% lower, end to end delay is 11ms to 165ms lower, routing overhead is 30 packets to 265 packets lower, throughput is 85 kbps to 450 kbps higher and energy efficiency is 75 joules to 200 joules higher when compared with the earlier baseline methods. In future direction to improve the network coverage and performance Internet of Things (IoT) technique is concentrated with satellite communication.

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