An Adaptive Hybrid Routing Scheme For Energy Management In Wireless Sensor Networks

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AN ADAPTIVE HYBRID ROUTING SCHEME FOR ENERGY MANAGEMENT IN WIRELESS SENSOR NETWORKS

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Abstract

In Wireless Sensor Network (WSN) the life time of nodes and energy management are important issues, because the nodes in WSN required more energy when it is used in different applications. On the other hand, unstable energy consumption among intermediate nodes tends to huge data loss. To address this problem the present research introduced a novel Hybrid Gossip Grey Wolf Ant lion (HGGW-AL) protocol to afford an efficient and better transmission channel. Here, the fitness of grey wolf and ant lion helps to categorize the energy drained node and also, to predict the malicious activities. Furthermore, the novel Rest Awake (RA) is initialized to process the clustering strategy to maintain the residual energy in WSN. Moreover, it enhances the energy level of sensor nodes by increasing its lifetime. Finally, the efficiency of the proposed strategy is compared with the existing works and achieved better performance by reducing the energy consumption of each sensor node.

Keywords: Routing protocol, Route maintenance, Grey wolf Ant lion, Transmission channel, Packet drop, Transmission ratio.

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Authors' contributions

Mr. Raviteja Kocherla (1st Author)

- Introduction
- Collection of literature
- Material properties
- Testing

Dr. M. Chandra sekhar (2nd Author)

- Conclusion
- Material properties

Dr. Ramesh Vatambeti (3rd Author)

- Casting of specimens
- Test result
- comparison

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1. Introduction

The WSN is a structured or structure less networks [1], which doesn't have any fixed topology [2]. But the structured network has static topology and the structured less networks changes its location randomly [3]. Considering wireless network [4], the WSN have an efficient path creation strategy [5]. Wireless Sensor Networks are of two types, they are static and dynamic [6]. In static network all the nodes are arranged as fixed and in dynamic topology [7] the nodes are present in dynamic manner [8]. However, specifying the communication system in WSN is a critical and difficult task because of continuously changing nodes [9]. Clustering is one of the actions to create the pack of similar objects [10]. Several researchers were performed experiments in clustering strategy [11]. From that they verified that nodes in a clustered WSN [12] also be Categorized as primary and secondary nodes [13]. In that, the Primary nodes can execute data processing and data aggregation process and the secondary nodes only achieves the data forwarding role. [14] Also, the wake time of sensor network channel is defined on the basis of power consumption of each individual sensor

node [15]; In addition, the WSN is typically consists of multi senor nodes that are of low power and low cost.

The WSN is more advanced considering conventional wireless network medium [16]. Also, while comparing conventional wireless network it reduces the packet transmission time enormously [17]. In the military section WSN is an integral part for searching and sensing the information also it can be deployed in hostile [18] or any other region without any fixed infrastructure, this is main advancement in sensor technology [19]. However it is outperformed in energy management scheme because in sensor network the node consumes more energy. To end these issues many researchers are implemented some efficient techniques such as clustering strategy [26], efficient energy enhancement [27], congestion control [25], etc. But still the suitable solution is a great issue, so maintaining the energy in WSN is an important framework. Thus the current research aimed to develop a hybrid routing model to predict the energy drained before the message transfer.

The key contributions of this current research are summarized below,

- Initially, develop the HGGW-AL protocol for the data distribution process.
- The fitness model of Grey wolf and Ant lion is helpful to predict the energy drained nodes.
- Rest awake protocol to maintain the energy in WSN.
- Finally, the density of nodes is increased and the packet drop ratio as well as energy consumption are reduced.

The remainder of this research is itemized as follows, section 2 describes recent literature related to energy management in wireless sensor network, section 3 defines problem statement, section 4 deals with proposed methodology, section 5 enumerates results and discussions and section 6 concludes the paper.

2. Related work

The important task of a WSN is to observe a generous area based on required applications. Moreover, the nodes which are present in WSN can communicate with each other wirelessly also the multiple hops[1] leads to non-uniformity of energy-consumption. For this reason, AlthiyaEby Irish et al [20] projected Dynamic Sink Mobility (DSM) to collect the statistics approach. Also, the proposed strategy is implemented in Network Simulator2 (NS2) platform and its efficiency was compared with different dynamic strategies.

The claim of high-performance WSN is mounting very fast but the sensor nodes requires more power utilization that endangered the lifetime of WSN. So Vilabha S. Patil et al [21] proposed power-saving strategies for sensor nodes with power executive unit. Moreover, the power executive unit is controlled by supportive custom elements with parallel implementation on Field Programmable Gate Array (FPGA). Thus, the implemented model can proficiently

[1]multiple routing based on the short path

manage energy utilization.

One of the drawbacks of WSNs is how to collect information from sensors via resource-constrained wireless network architecture; the sensor nodes are outfitted with Radio Frequency (RF) circuit to produce energy from mobile nodes. Thus, Yong Liua et al [22] presented an energy harvesting scheme and scheduling mechanism to maintain the energy management strategy in an efficient way. Furthermore, the performance and feasibility are validated by experimental results.

Wireless sensor-based networks can emerge a new trend in today's modern society; thus, the benefit of the WSN model is more popular, even though it has some limitations such as energy management, security management, etc. So Sunny Katyara et al [23] developed a new model as switch yard based system architecture, which is connected with the grid system. Moreover, the proposed approach achieved less energy utilization and high control strategies.

Commonly, WSN strategies are used to monitor or investigate the application; the nodes in WSN are the sensor nodes that have the capabilities to monitor specified applications. The energy drained battery also works for a short time, also restoring the sensor batteries are very expensive. So, Sara Kassan et al [24] proposed an energy harvesting policy to recharge the sensor batteries. Finally, the comparison charts proved the effectiveness of the proposed strategy in a high manner.

3. Problem statement

The chief problem in WSN is energy consumption, the more energy consumption node has less life time. If the node is disabled then packet drop will occur, in sensing technology the packet loss or data flow cause huge damage to all appliance . The occurrence of the link failure elaborated in figure.1.

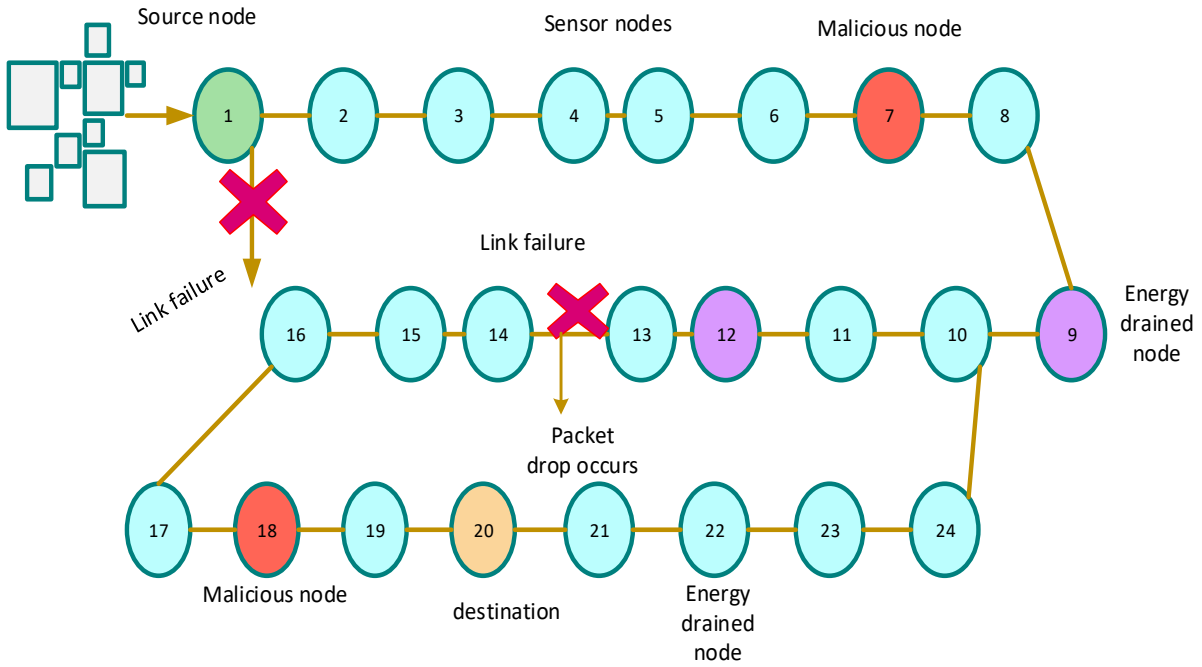


Figure.1 System model

So implementing the hybrid algorithm might maintain the energy management in WSN also take aware about the energy drained node before the data transmission.

4. Proposed methodology

The Awareness of energy in WSN is the important metric because considering wireless network, the WSN has many facilities from sensing the information up to packet forwarding. The current research work proposed HGGW-AL with Rest Awake (RA) protocol to end this problem. Initially, the HGGW-AL is utilized to create the sensor nodes then the fitness of grey wolf and ant lion is utilized to predict the energy drained and malicious nodes. Furthermore, RA is initiated to manage the energy in WSN by clustering approach. The process of proposed methodology is elaborated in figure.2.

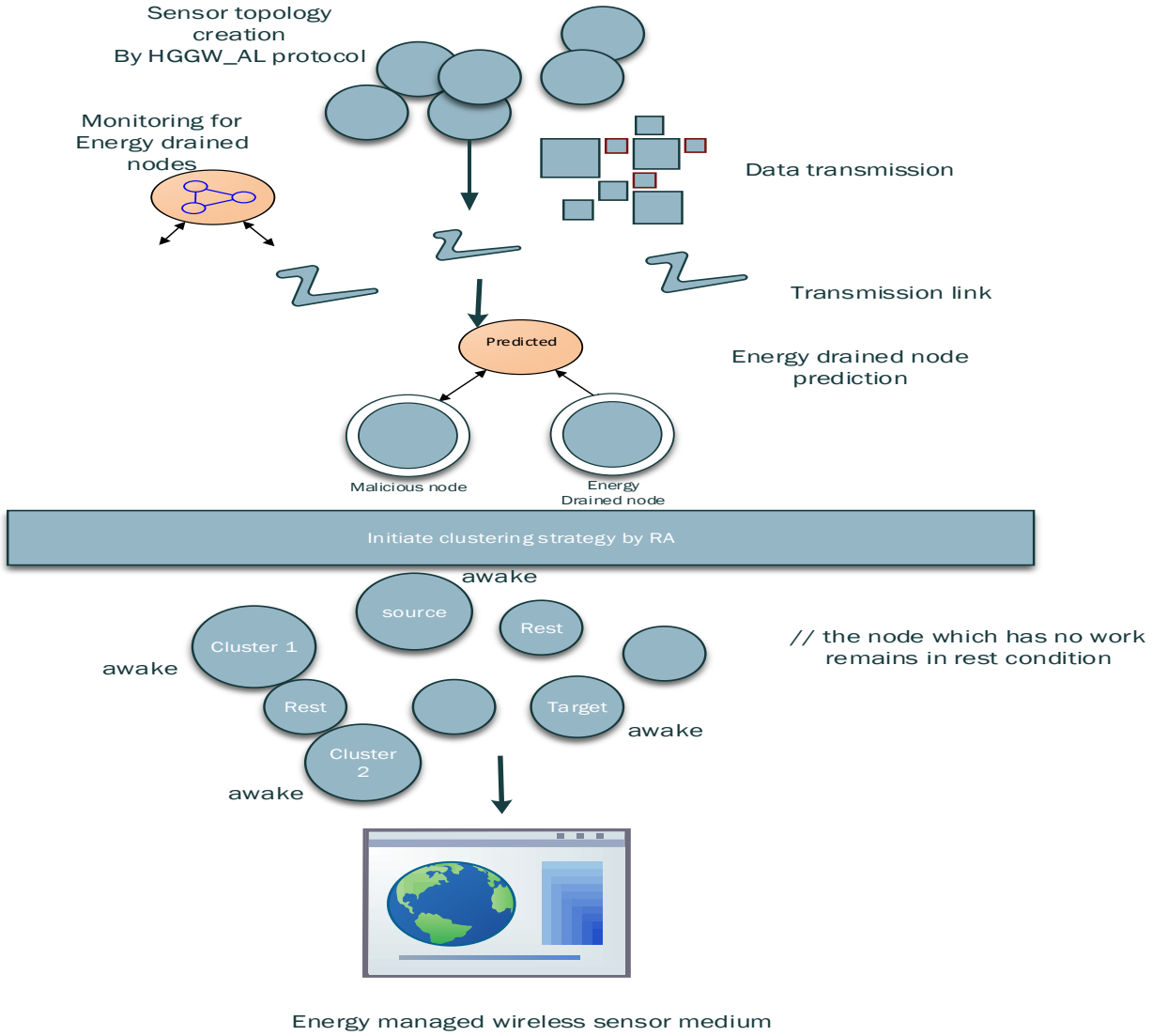


Figure.2 Proposed (HGGW_AL with RA)

4.1Hybrid Gossip Grey Wolf-Ant Lion (HGGW-AL) protocol

There are dual conventional procedures to relay the information or data in the sensor network channel without any maintenance in topology and multifarious routing algorithms. In addition, this type of protocols could not estimate the capacity of nodes before transferring or broadcasting the message or packets. It continues the process till all the nodes received the data or the message reaches to its destination. In this current research work, grey wolf and ant lion model [24] is adopted to invent the new hybrid model. In the initial phase, the grey wolf fitness parameter is initialized as alpha(α), beta(β), delta(δ) and omega(ω). Here the (α) is to investigate all the sensor nodes and collect the status of node. Consequently, the packets are transferred to light weight node which has long life time. Here malicious node is termed as ω and the energy drained node is termed as (δ).

G_i is the source or event capturing node and G_j is the server or destination which means the collected information have to be reached at node G_j that is detailed in eqn. (1). To transfer the packets the nodes energy should be estimated in eqn. (2).

$$G_i = G_j + Packets \tag{1}$$

$$G_i = packets_j + node \quad energy \tag{2}$$

Once the event is sensed by a sensor node, then the source node should monitor the entire node to estimate the malicious and energy drained node.

After the events are collected the source node wants to monitor all nodes for energy drained and good nodes. The monitoring function of HGGW-AL is in the format of eqn. (3), here the sensor network architecture is represented as M and monitoring element is represented as α . In addition, the good node is evaluated by β, energy drained node is represented by δ and the malicious node is represented as ω. Thus the evaluation of good nodes, malicious nodes and energy drained nodes is validated by eqn. (3). here, D is the frequency range of each node.

$$M = |D_1 \cdot R_\alpha - R|,\ M_\beta = |D_2 \cdot R_\beta - R|,\ M_{\&} = |D_3 \cdot R_\delta - R| \tag{3}$$

The energy drained node is formulated by the following eqn.(4),

$$nodeR = \frac{R_a + R_e}{2} \tag{4}$$

Here, R_a is the required energy to transfer the packet and R_e is the energy of each individual nodes is calculated separately in the order of eqn. (5)

$$R_{\alpha\&} = R_{\alpha\&} + R\,,\ R_{\beta\&} = R_{\beta\&} + R\ ,\ R_{\delta\&} = R_{\delta\&} + R \tag{5}$$

Here the frequency range is calculated to estimate the specified node, if it has the capacity to transfer the information or not that is detailed in eqn. (6).

$$R_{\alpha} = D_{\alpha\&} + R\,, R_{3\beta\&} = D_{\beta\&} + R\ , R_{\delta\&} = D_{\delta\&} + R \tag{6}$$

If the energy drained node and malicious node is estimated then it initiate the rest awake protocol to maintain the energy.

Algorithm 1Pseudo code for application based HGW-AL model

Initialize *the number of sensor nodes* $R(i = 1,2,\ldots n)$

Begin *with sensing the events which have to be processed the collected node is termed as source node*

Estimate *the fitness of the all nodes in M*

(α) *parameter is upgraded to monitor all present nodes in sensor networks*

if *R is the each individual nodes then* $R > 1$ *or* $|R| < -1$*, is the energy drained nodes*

$$R \quad = 0.2 \le \alpha \le 0.5 \tag{7}$$

The predicted node energy by an alpha is in between 0.2 and 0.5 then it is termed as good node

β *//Beta is termed as good node*

δ *// Energy drained node*

while *(t < total number of sensor nodes)*

for *each monitoring agent* (α)

The good node that is identified by eqn.(7) is termed as β

end for

Update δ *and* ω *(predict energy drained node, and malicious node*

end

Node energy $R\max$,

establish the ***best while***($R_i > R_i \max$) *maximum required energy to transfer the packet*

Initiate *iteration number* $R_i = 2$

While($R_{i\,crr} < R_i \max$)

for *entire sensor network* ($j = destination$)

for *every dimension*($G = (R)$

Initiate with uniform distribution of energy by eqn.(6)

end for

for *every* $R(i = 0)$ *Fault is detected(energy drained node and malicious node)*

end for

Increment iteration $t_{icrr} = Energy \quad management protocol$

end while

4.2 Rest Awake Protocol

The procedure, sleep wake is distinct for all nodes, thus the nodes present in current WSN not needed any other procedure to process its function. Here the WSN nodes are represented as M, each and every sensor node is in charge while predicting any events. If any one of the nodes predicts an event or tragedy, then that specified pack the information or data to forward it to the sink by routing.

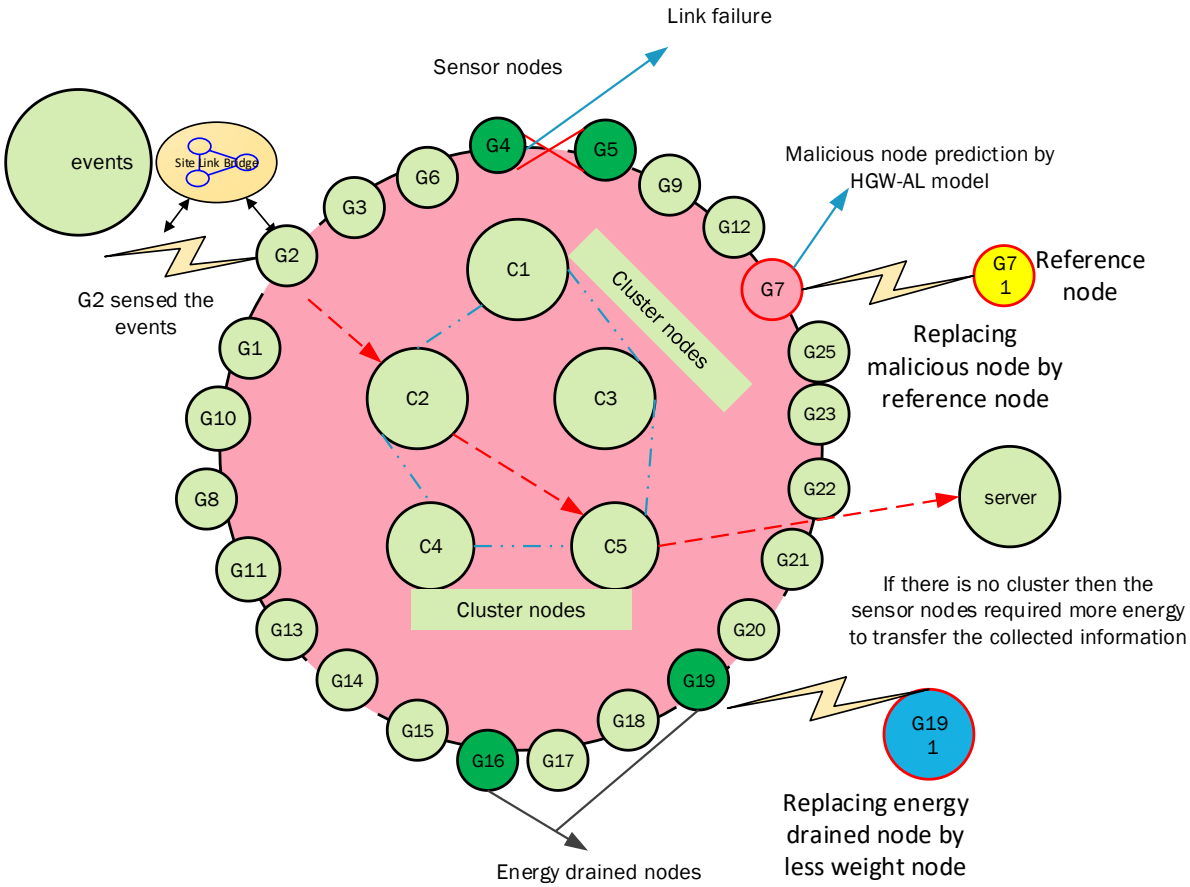


Figure.3 RA Mechanism

Algorithm.2 Rest Awake

Initiate *RA*

if $node = cluster$ *then*

$node = energy\_packet\,transmission$

$node \quad status = awake$

if $node = energy\_no\,packet \quad transmission$

$node \quad status = rest$

// if there is no packet transmission then the node status remains rest condition to save the energy

else if

$neighbor \quad node\_ \quad dead$

// if the neighbour cluster is in dead condition then the current node status is awake.

$node \quad status = awake$

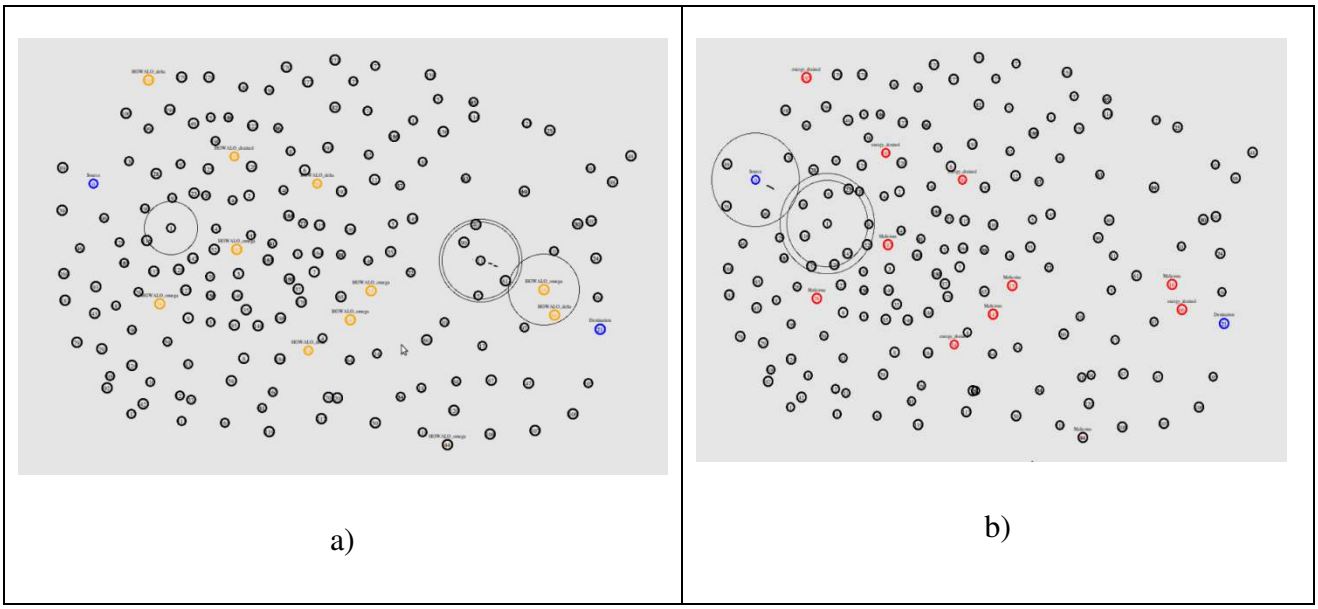
End

The node in network chooses the random power levels to transfer the data. The designed WSN has a cluster node to gather all the information that is collected by the individual sub nodes. The WSN without cluster formation can drain the energy very fast so to overcome this problem the cluster scheme is introduced. The usage of cluster head in WSN is to collect the information from all the neighbors and transmits it to the near sink to reach the destination.

5. Results and Discussion

The current research work is implemented using Network Simulator 2 running in Ubuntu platform. The energy management in WSN became serious threat against wireless strategy because the sensor nodes are powered by batteries. HGGW-AL model is utilized in this current research to transfer the data. Moreover, the proposed model can able to predict the energy drained and malicious node in earlier stage. Consequently, Rest Aware (RA) protocol is utilized to maintain the route by providing reference link.

The node creation using network simulator is defined in figure 4. Initially the nodes are created using gossip protocol then the energy drained and malicious node is identified by the hybrid optimization model.



a) b)

Figure.4. a) Monitoring the WSN node b) malicious and energy drained node prediction

5.1 Case study

The road condition analysis is shown in figure.5. In this modernized world, road safety is the important concern to avoid accident and poor transportation facilities. So the developed sensor

technology applied in road to check its strength and weakness. At the beginning 200 number of sensor nodes are created with the use of HGGW_AL protocol to sense the road condition, which is defined in eqn. (8).

$$R(i = 1,2,....200)$$

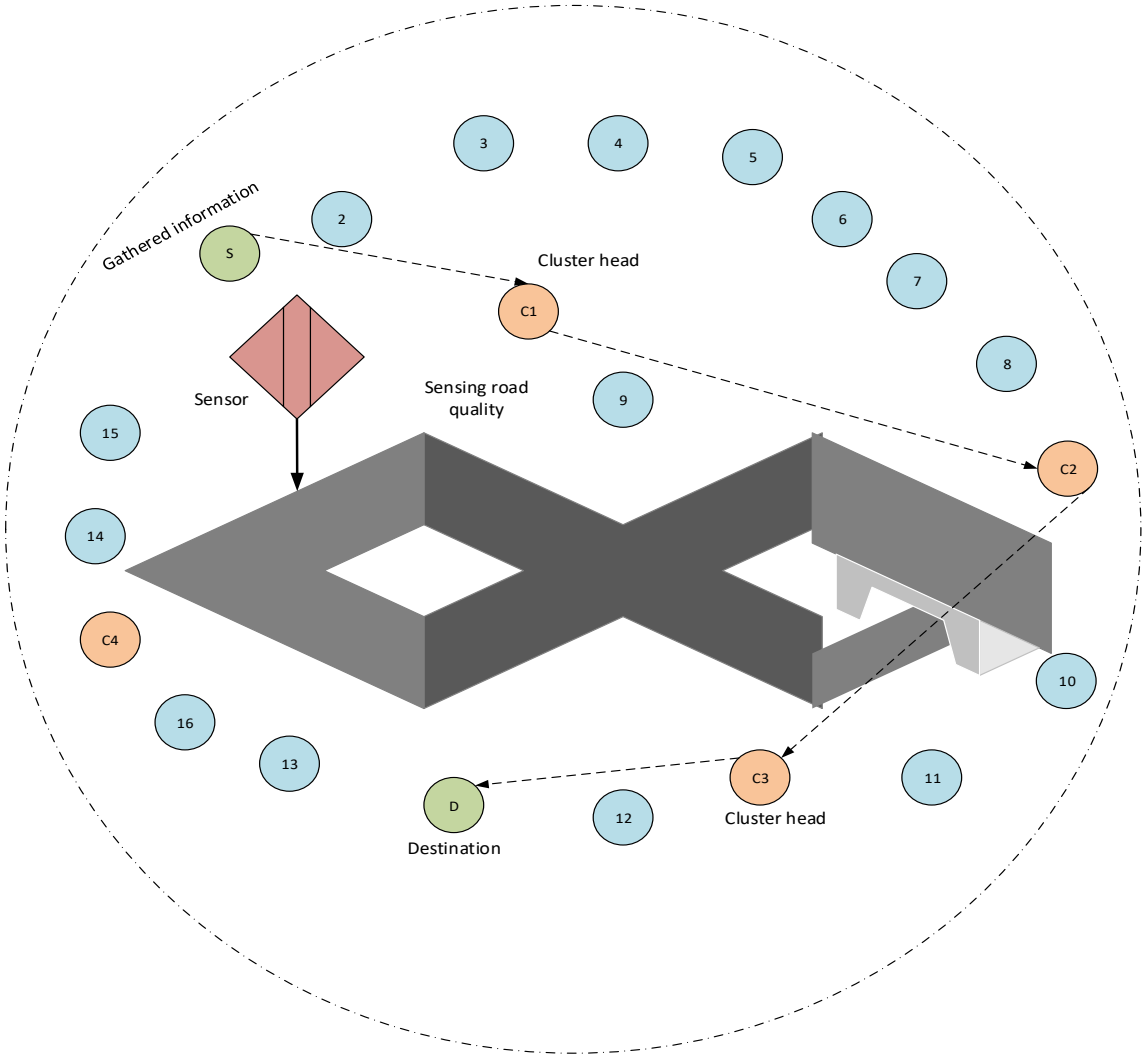


Figure.5 Road condition analysis

In sensor network the first node is constructed as source node and 6th node is considered as destination node from the eqn. (1), eqn. (9) is obtained

$$1 = 6 + 1000 bits \tag{9}$$

To transfer the sensed information without any crash the information about node energy is important that is estimated using eqn. (2) the estimated formation is shown in eqn. (10)

$$G_i = 1000b + 0.2 \tag{10}$$

Here the 0.2 is the energy of the source node, once the information is collected all node energy should be estimated that process is happened in the form of eqn. (3) which is functioned in eqn. (11).

$$M = \left|0.2 \cdot R_\alpha - 1\right|,\ M_\beta = \left|0.2 \cdot R_\beta - 1\right|,\ M_{\delta\&} = \left|0.2 \cdot R_\delta - 1\right| \tag{11}$$

After this monitoring function of eqn. (11) then it checks the energy drained condition using eqn. (7) if the condition is met then it is classified as malicious node and energy drained nodes.

5.2 Performance metrics

The efficiency of the proposed model is compared with existing works in terms of some important metrics such as packet delivery ratio, packet drop ratio, energy overhead, transmission ratio, throughput ratio, energy consumption and node lifetime

In order to evaluate the performance of the proposed technology with other methods; some of the techniques are adopted such as **congestion algorithm based on rate based [25], Multi-layer clustering architecture** [26], and Enhanced Energy Management scheme in Energy Harvesting Wireless Sensor Networks (EEM-EHWSN) [27].

The rate based congestion (RBC) algorithm is utilized in WSN to reduce the energy consumption and packet drop ratio. Moreover, the energy is optimized using optimization mechanism. The congestion function is processed with clustering mechanism, thus the presence of clustering head tremendously reduce the energy consumption in wireless sensor network.

Multilayer clustering (MC) architecture is utilized in WSN to maintain the stable energy. Here, the energy is maintained by the threshold level of residual energy, with the residual energy the WSN node is processed in forward and backward rotation.

EEM-EHWSN strategy utilized Multiple Access with Collision Avoidance (CSMA/CA) protocol, for the message transmission; in this model the busy channel is informed by the carrier waves, at that time receiver listen the carrier waves in wireless channel to avoid network traffic. If there is no nodes or hubs are ready to retain the message then the source node couldn't forward the message this approach reduced the wasting of energy. Consequently, if the medium is free then the acknowledgement will be sent to the source node that the receiver node is ready to accept the packets. After this information the process is done. Network lifetime by varying the node density is shown in figure.6.

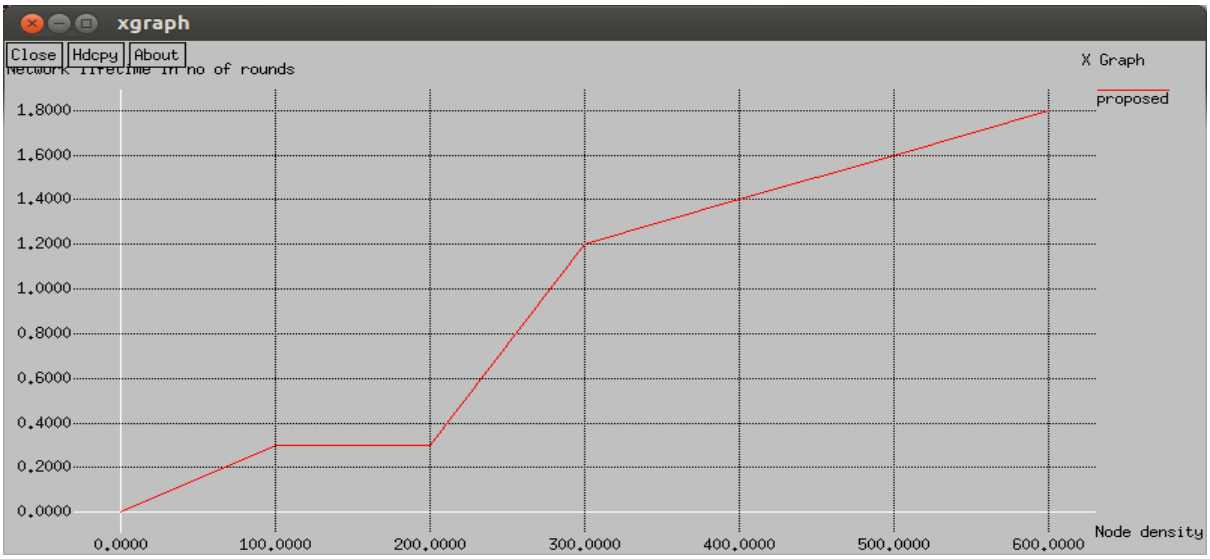


Figure.6 Network life time

5.2.1 Transmission ratio

In wireless network medium a WSN is the specialized network system, that have two major components such as base station and nodes, the each nodes in sensor environment have sensing capacity. In addition, that sensing capacity is helpful to sense the information in the specified event. The transmission ratio is defined as how rapidly the message reaches to the destination or target which is evaluate using eqn. (12). Here, N^* is the bit interval.

$$N^* = \frac{1}{frequency} \tag{12}$$

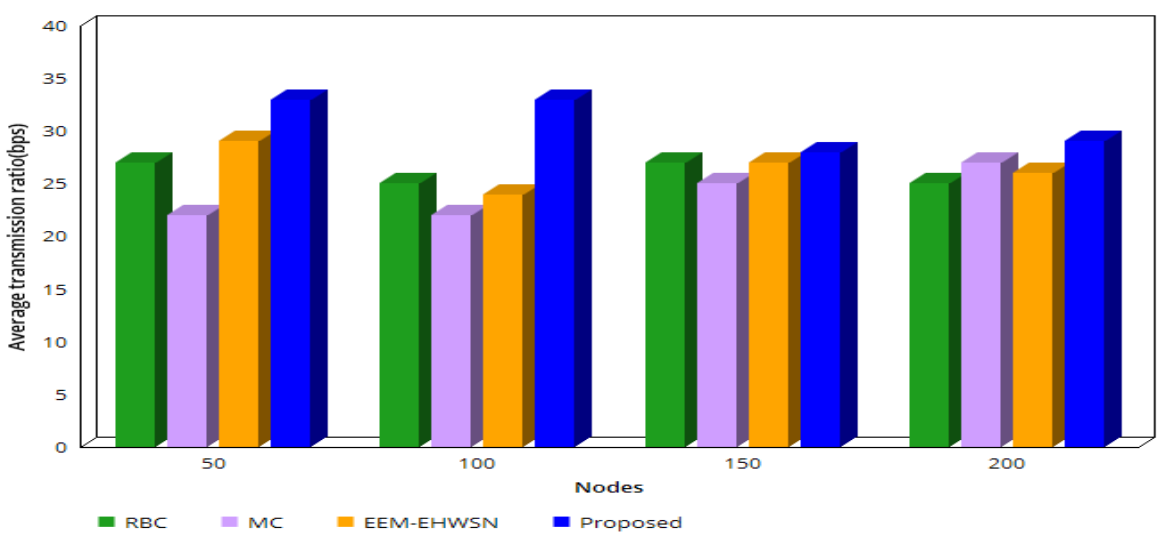


Figure 7: Comparison of packet transmission ratio with existing technique

Transmission capacity (TC) is one of the performance metrics in WSN that calculates the spatial strength of successful broadcasting per unit area. The successful transmission ratio between source and destination hub for the proposed scheme is shown in Figure. 7. Moreover, the value of the proposed model is obtained by NS2tool. The comparison of the transmission ratio with existing work is elaborated in Figure.7 and Table1.

Table.1Average Transmission ratio

Average Transmission ratio (bps)			
RBC	**MC**	**EEM-EHWSN**	**Proposed (AB_TTDD with TEMA)**
29	27	22	33
24	25	22	33
27	37	25	28
26	25	27	29
25	27	24	35
27	28	30	35

The transmission ratio is calculated based on the running time of simulation and network size, which is evaluated how speedily it reaches the server or destination.

5.2.2Packet drop ratio

The error in transmission channel cause packet drop in wireless medium, moreover it is vulnerable to attack because, in WSN the node drained its energy in an enormous way. The packet drop ratio is evaluated as the number received packet by total number of packet in eqn.(13).

$$Packet \quad drop = \frac{Number of \quad received \quad packet}{Total number \quad of \quad packets} \tag{13}$$

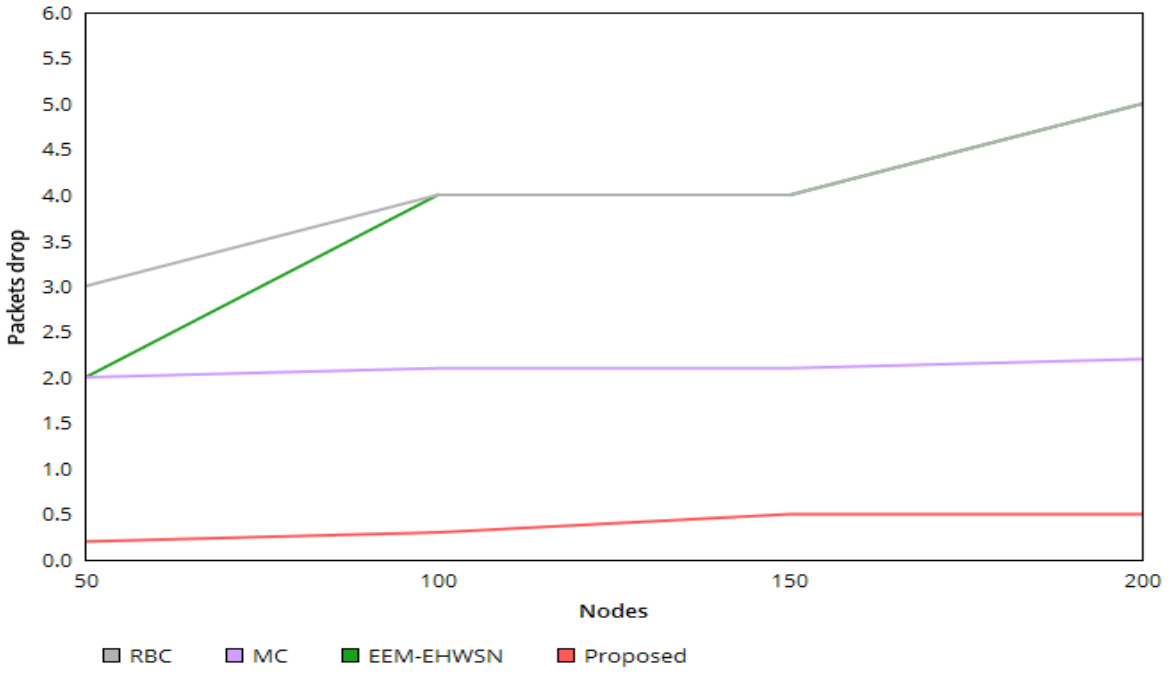


Figure 8: Comparison of packet drop ratio with existing technique

If there is any energy drained node then link failure is happened, these link failures tend to huge data or packet loss. The comparison of packet loss metrics is shown in figure.8 and table 2.

Table.2 Packet drop ratio

Nodes	Packet drop ratio			
	RBC	**MC**	**EEM-EHWSN**	**proposed**
50	3	2	2	0.2
100	4	2	4	0.3
150	4	2	4	0.5
200	5	2	5	0.5

The comparison of packet flow ratio is evaluated between 200 numbers of nodes, the obtained packet drop ratio by HGGW-AL with RA is 0.5% for 200 number of nodes that is detailed in table.2.

5.2.3Throughput ratio

Throughput is one of the significant metrics in WSN to evaluate the effectiveness of the network quality and connection. The unsuccessful data transmission might degrade the throughput performance of the entire system. Thus the through ratio is evaluated based received data or message by time taken. The achieve throughput ratio and its comparison is shown in figure. 9; the throughput ratio is calculated using eqn. (14).

$$Throughput = \frac{packets \quad received}{Time \quad taken} \tag{14}$$

To provide an efficient transmission channel the data evaluation is more important, the calculation of the data length is termed as throughput which is measured in bits per second of a data transmission link designed in figure.9. The throughput ratio is generated by changing the number of nodes, the result validation shows that the throughput is decreased while the number of nodes are increased.

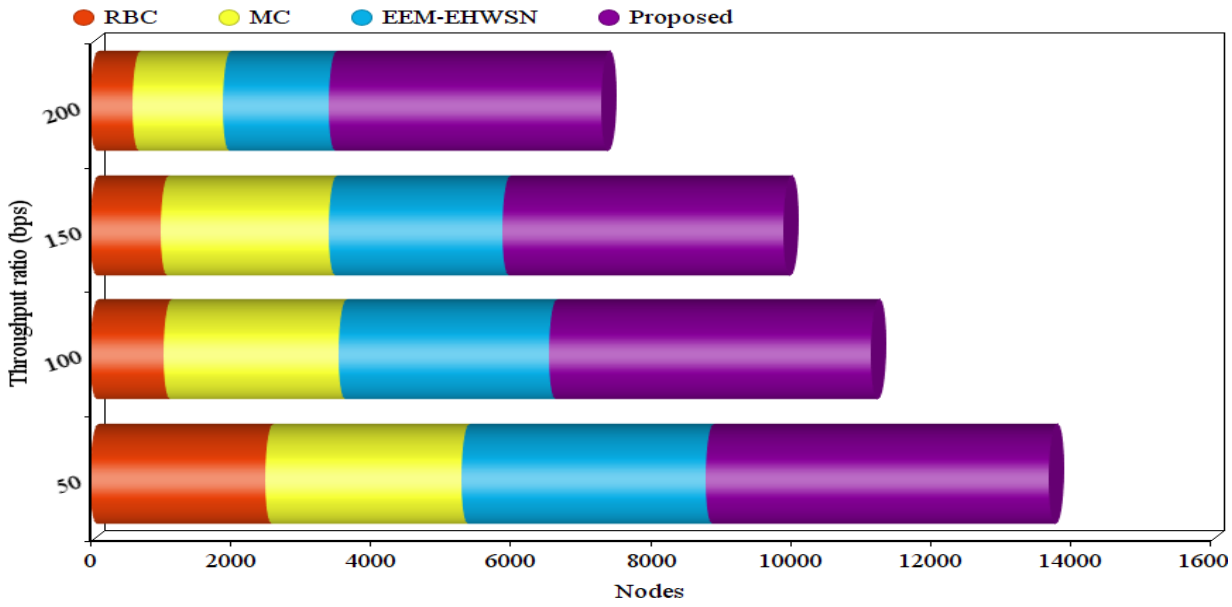


Figure.9 Node versus throughput ratio

The time taken for the acknowledged packet to reach their desination or target nodes is defined as throughput ratio. The achevied throughput ratio and it comparison statistic is elaborated in table. 3.

Table.3 Throughput ratio validation

No. of nodes	Throughput ratio (bps) validation			
	RBC	MC	EEM-EHWSN	proposed (AB_TTDD with TEMA)
50	2500	2800	3500	4900
100	1600	2500	3000	4600
150	1550	2400	2500	4000
200	1000	1300	1500	3900

5.2.4 Energy Consumption (J)

In less data range field a sensor consumes less energy to transmit the packet. So reducing the data coverage area provide the optimized energy consumption rate, also it increases the life time of node. The proposed method obtained less energy consumption with the use of route maintenance strategy., shown in figure 10 and table 4.

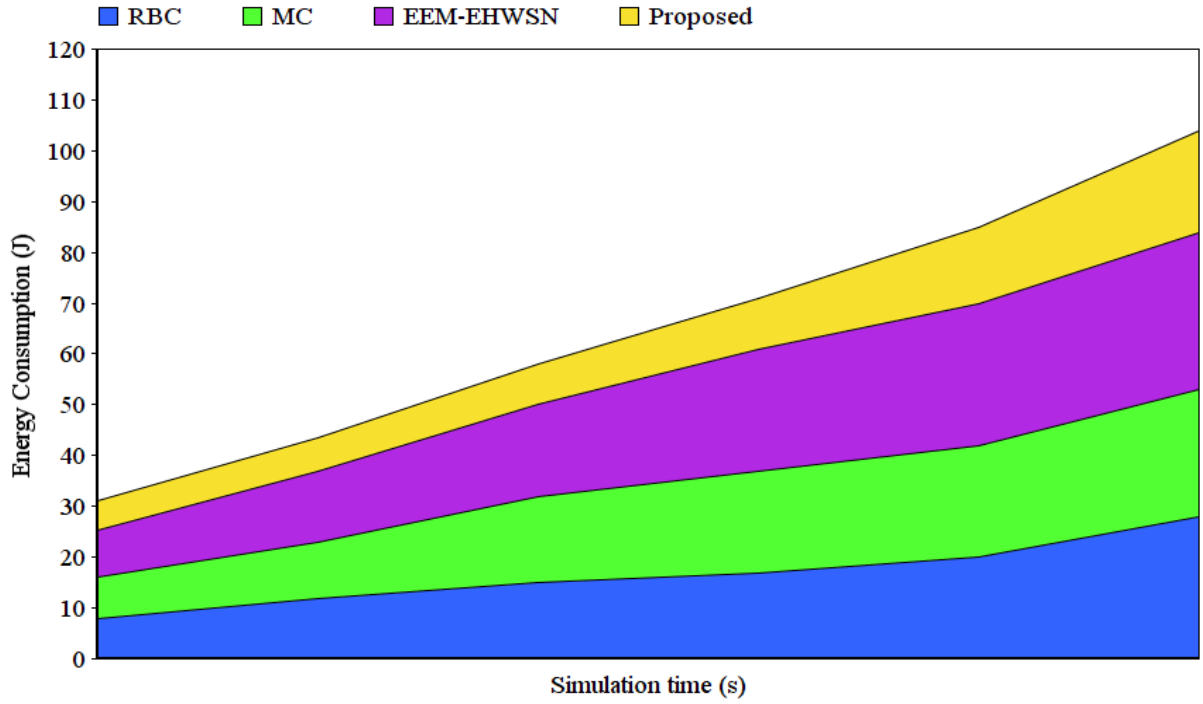


Figure 10: Simulation time versus energy consumption

In MIMO the energy consumption of wireless sensor network is validated with different density of nodes.

Table.4 Energy Consumption

Simulation time (s)	Energy Consumption (J)			
	RBC	MC	EEM-EHWSN	proposed
5	8	8	8.2	6
10	20	11	10.9	9
15	17	15	14	12
20	27	20	17	15
25	31	27	25	20
30	31	27	25	20

The energy consumption of the wireless sensor network is validated based on simulation time. Compared with the existing approach, the proposed strategy HGGW-AL with RA has reduced energy consumption as 20 J at the simulation time 30s.

5.2.5 Energy Overhead

The power consumed in the simulation phase to transfer the communication is known as overhead energy, which is defined as the required energy to transfer the packet. So the power reduction in the WSN model is very important to provide an efficient data transmission channel.

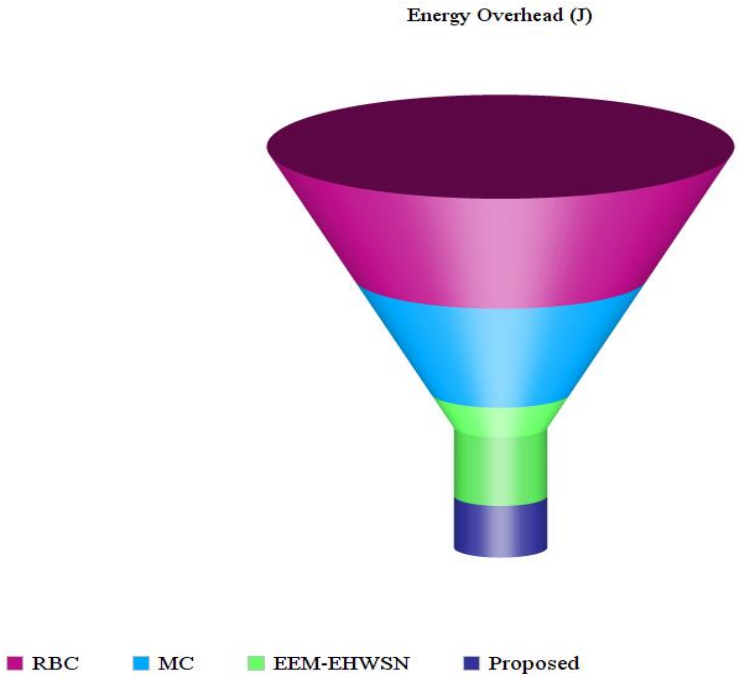


Figure.11 Comparison of energy overhead

Thus, the overhead energy is evaluated by the HGGW-AL with RA model is 0.04 J for 100 numbers of nodes and 0.4J for 350 nodes that are detailed in Figure. 11 and Table5.It was not expedient to revitalize the battery of sensor nodes, so the power competence was a great deal for sensor network.

Table.5 Statistics of energy overhead

Nodes	Energy overhead (J)			
	RBC	MC	EEM-EHWSN	proposed (AB_TTDD with TEMA)
100	0.91	0.7	0.08	0.04
150	1	0.9	0.09	0.044
200	1.2	0.91	0.4	0.051

5.2.6 Residual Energy

After the packet transferring process, the WSN must keep the balance energy to gather the information and transfer it to the server. Here, the remaining energy of each sensor node is defined as residual energy that is elaborated in figure.12 and table 6.

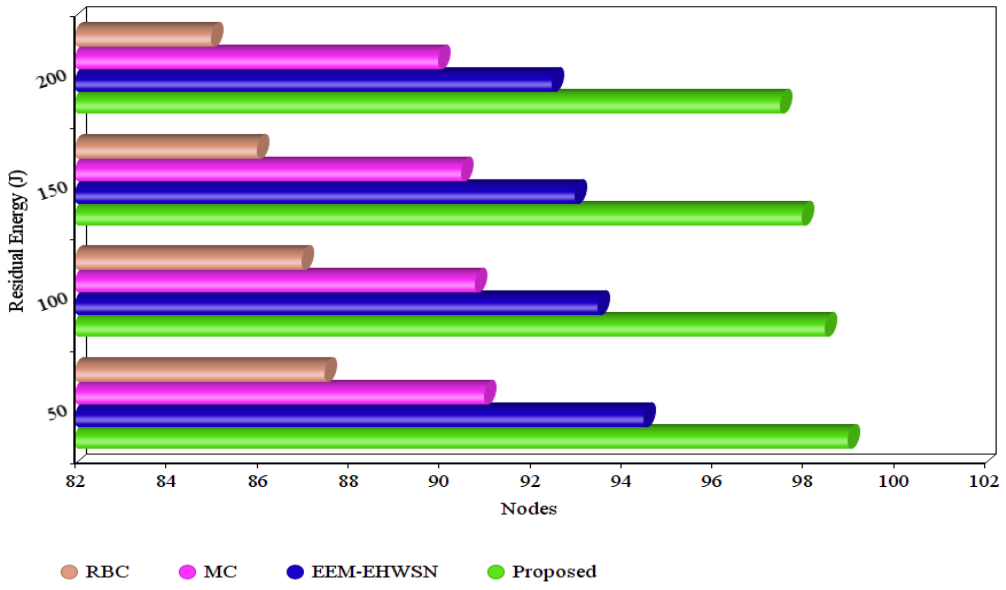


Figure.12 Network size versus residual energy

In this current work, the size of the network is constructed from 50 to 200 nodes. The obtained residual energy by the current research model is maximum 99.9J within 200 number of nodes.

Table.6 Residual energy

Network Size	Residual energy (J)			
	SEEC	MIMO	EEM-EHWSN	proposed
100	88	91	94	99.
150	87.5	90.8	93.7	98.8
200	87	90.5	93	98

During the data transmission if any one of the links is failed then it takes some time for recovering the link, this is thechief reason behind in latency validation. To overcome this problem the developed model introduced HGGW-AL with RAto detect link failure in an earlier stage. Immediately, the TEMA initialized the process of route maintenance.

5.2.7Delay in second (s)

The malicious activities and energy drained node cause delay in network transmission channel because when the link is broken the information is saty in previous buffer till the link is active. In addition, the data traffic also cause delay in data transmission. The aatained delay rate and their comparion with existing works is detailed in figure.13.

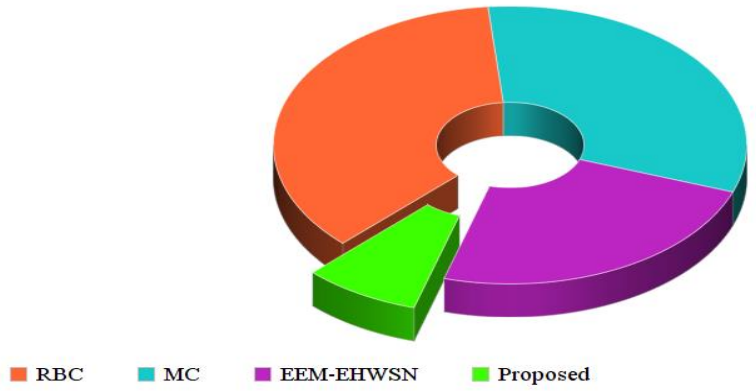


Fig.13 Latency Measure

Delay is the time taken for a data to be broadcasted through the network channel from source to destination. The reduction of the delay rate can maximize the transmission ratio. Within the 100 number of nodes, the attained latency measure by HGGW-AL with RA is 0.4s, out of 150 numbers of nodes the delay measure is 0.6s, and also for 350 numbers of nodes the latency measure is 0.91s which is elaborated in Table 7 and Figure.13.

Table.7 Latency Comparison

No. of nodes	Latency (s) Comparison			
	RBC	**MC**	**EEM-EHWSN**	**proposed**
100	0.91	0.8	0.7	0. 2
150	1	0.93	0.9	0.25
200	1.4	1.2	1	0. 3

5.3 Discussion

Thus, the statistics proved that the proposed HGGW-AL with RA attained very low latency ratio while comparing the existing works. The overall comparison results proved the efficiency of the current research work; also it assures that the proposed strategy is applicable in WSN channel to enhance its performance.

6. Conclusion

Nowadays, WSN is applicable for all applications, although maintaining stable energy is a critical issue. Moreover, when the numbers of sensor nodes are increased at that time the transmission ratio between source and destination is decreased. The planed HGGW-AL routing protocol provided a proficient and uninterrupted transmission channel in WSN. Thus, the communication channel is secured by the early prediction of the proposed model. Once the less energy nodes are announced, immediately the RA mechanism is activated to maintain the energy by initiating the clustering model. Furthermore, while comparing the existing model the proposed mechanism reduced the packet drop ratio as 99% and error rate as 98.5% also it attained maximum throughput as 4900b/s. Thus, the implemented strategy is utilized to enhance the WSN environment by reducing packet drop and energy consumption.

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