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## Research Article

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# MULTIVARIATE WEIGHTED ISOTONIC REGRESSIVE MODEST ADAPTIVE BOOSTING BASED RESOURCE-AWARE ROUTING IN WSN

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## ABSTRACT

WSN includes a scenario where huge amount of sensor nodes are distributed to monitor environmental conditions with route collected data towards sinks via the internet. WSNs efficiently manage the wider network with available resources, such as residual energy and wireless channel bandwidth. Therefore, routing algorithm is important to enhance battery-constrained networks. Many existing techniques are developed for balancing consumption of energy but efficient routing was not achieved. Multivariate Weighted Isotonic Regressive Modest Adaptive Boosting based Resource Aware Routing (MWIRMAB-RAR) technique is introduced for enhancing routing. The MWIRMAB-RAR technique includes a different process namely resource-aware node selection, route path discovery, and data transmission. Initially, the MWIRMAB-RAR technique uses the Modest Adaptive Boosting technique uses the Multivariate Weighted Isotonic Regression function for detecting resource-efficient sensor nodes for effective data transmission. After that, multiple route paths are established based on the time of flight method. After establishes route path, source node sends data packets to sink node via resource-efficient nodes. The data delivery was enhanced and minimizes packet loss as well as delay. The simulation analysis is carried out on certain performance factors such as energy consumption, packet delivery ratio, packet loss rate, and delay with number of data packets and sensor nodes. The obtained evaluation indicates MWIRMAB-RAR outperforms well in terms of increasing data packet delivery and reduces consumption of energy, packet loss rate, and delay.

**Keywords:** WSN, Routing, Modest Adaptive Boosting, Multivariate Weighted Isotonic Regression

## 1. INTRODUCTION

WSNs are fundamental for a variety of significant utilization where huge amount of sensor devices were developed in monitoring field. Such kinds of sensor nodes suffer as restricted processing ability and energy. Since the nodes exist for extended time for enhancing the network lifetime during the data transmission to sink node via multi-hop routing. The sink node is dependable to make suitable decision depend on received data. Energy conservation is the demanding problem in WSN. Several existing routing techniques were introduced but balancing consumption of energy and enhance battery life of sensor nodes are still challenging issues in the distributed wireless network.

E3AF based reliable routing algorithm was introduced in [1] for improving data transmission consistency. However, it was not efficient to find better resource efficient sensor nodes in order to further increase the network lifetime. Energy-Efficient Cooperative Routing method for Heterogeneous WSN (EERH) was developed in [2] to extend the network lifetime. However, the designed routing failed to increase the reliable data delivery with minimum delay.

A routing strategy with a Greedy algorithm was introduced in [3] to attain a better network lifetime. However, the designed algorithm failed to apply the machine learning technique for improving the routing performance. DS-EERA was introduced in [4] to enhance the data communication with minimum packet loss. However, the designed routing algorithm was not efficient to decrease the end-to-end delay of data communication.

In order to minimize latency, Energy-efficient routing-aware network coding-based data transmission was introduced in [5]. However, it failed to enhance routing and transmission. RBM Routing Protocol is designed in [6] for enhancing network throughput with lifetime of network. However routing nodes were not considered the transmission distance to further save the energy.

An efficient routing technique is designed in [7] to route data from sensor nodes to sink. However, efficient routing approaches were not considered to extend the network lifetime. FBR technique is designed in [8] for minimizing computation overhead and increase the delivery ratio. However, it failed to evaluate performance of FBR method with mobile node scenarios. ECRP is designed in [9] for increasing network lifetime and energy efficiency. However, performance of ECRP was unsuccessful for handling mobility.

An interference-aware energy-efficient routing algorithm (IA-EERA) is developed in [10] for expanding lifetime of network. However, designed algorithm failed to investigate mobility on energy-efficient routing.

### **1.1 Major contribution**

In order to solve the issues reviewed from the existing literature, a novel technique called the MWIRMAB-RAR technique is introduced with a novel contribution.

- To increase the resource-efficient routing in WSN, a novel technique called the MWIRMAB-RAR technique is introduced based on the ensemble technique.
- The MWIRMAB-RAR technique uses the Modest Adaptive Boosting technique for detecting resource with help of Multivariate Weighted Isotonic Regression function. The regression function analyzes the sensor node energy and bandwidth. Based on the regression analysis, the resource-efficient nodes are identified for enhancing data delivery with minimizes packet loss.
- To reduce delay, MWIRMAB-RAR technique uses the time of flight method to detect neighboring nodes for constructing route paths.
- Finally, the simulation analysis is carried out to show the performance of the MWIRMAB-RAR technique based on certain performance factors.

### **1.2 Paper Organization**

The article is organized as follows. Section 2 describes review of numerous energy-aware routing schemes. Section 3 presents description of proposed MWIRMAB-RAR technique. Section 4 presents simulation settings of proposed and existing routing schemes. Section 5 explains performance evaluation of MWIRMAB-RAR technique compared with existing method. Section 6 describes conclusion of article.

## **2. RELATED WORKS**

Energy-Efficient Routing Protocol based on Reinforcement Learning (ERP-RL) was introduced in [11] to improve the network lifetime and scalability. However, it failed to consider selecting the more optimal routing protocol to improve reliable data transmission. A novel energy-aware and reliable routing

protocol were introduced in [12] for packet transmission. However, the designed routing technique consumes a higher degree of complexity. A multi-objective fractional particle lion algorithm is developed in [13] to improve efficient data transmission. But, performance of data delivery ratio is not considered.

In order to improve transmission framework, Energy-Efficient Routing Protocol was designed in [14]. However, it was unsuccessful for enhancing better data transmission with reduced delay. Load Adaptive Beaconing Scheduling (LABS) algorithm was introduced in [15] to increase the optimum network throughput. The designed algorithm failed to achieve an efficient network lifetime.

RCER protocol is developed in [16] to improve lifetime of network with lesser routing cost. However, the designed protocol failed to measure the performance of network lifetime. Destination Oriented Routing Algorithm was introduced in [17] with optimum distance and direction for enhancing the lifespan. But, it was unsuccessful for transmitting packets with lesser delay.

In order to minimize energy utilization and attains better load balancing of data transmission, energy-efficient scalable routing algorithm was designed in [18]. But, higher delivery ratio was not achieved. Multi-Objective Based Clustering and SFO guided routing approach was introduced in [19] to improve energy efficiency. The designed routing algorithm failed to estimate the performance analysis of the delay of data transmission.

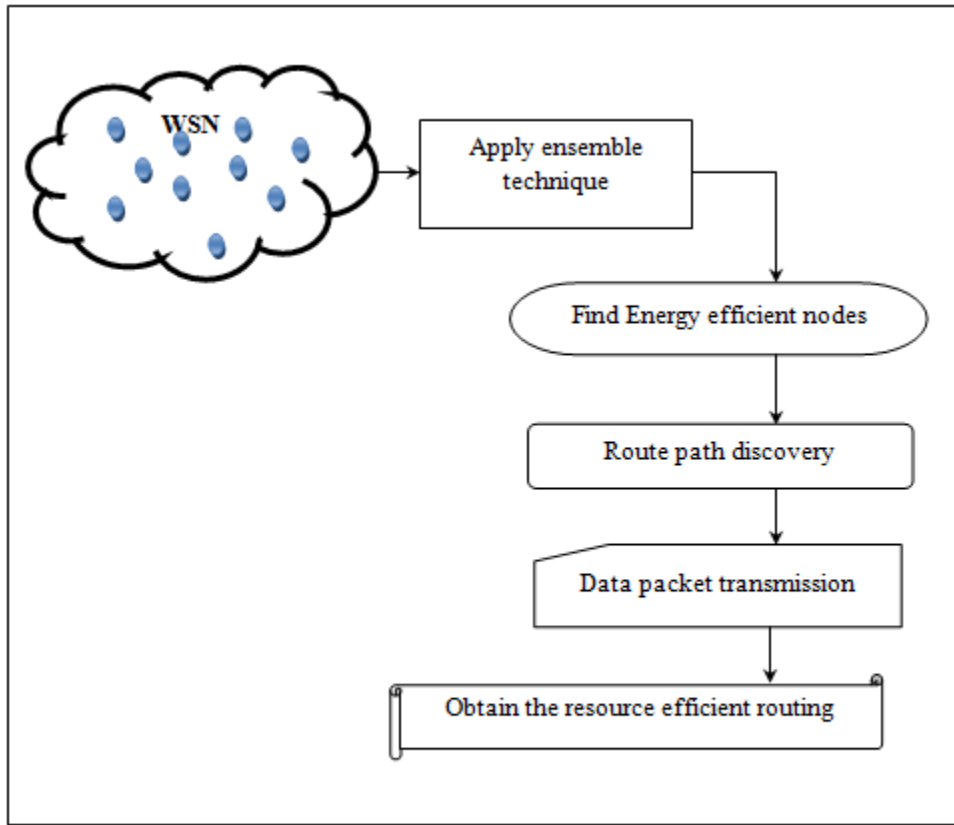
An energy-efficient region source routing protocol is introduced in [20] for enhancing data delivery as well as minimize the delay. However, the designed protocol failed to provide the theoretical analysis of network lifetime maximization.

### **3. METHODOLOGY**

WSN includes several sensor devices are developed in environmental area for remote sensing and monitoring various conditions. WSN is referred as gathering of self-organized device deployed in random way depend on ad-hoc infrastructure, for collection of data over network field. But resource-efficient routing in WSN is a challenging issue. Based on the motivation, a novel technique called the MWIRMAB-RAR technique is introduced

### 3.1 Network model

The network model of MWIRMAB-RAR architecture was discussed. In WSN, number of sensor nodes  $S_i = NS_1, NS_2, NS_3 \dots NS_n$  are randomly deployed in a squared grid structure ' $m * m$ ' with respect to certain transmission range ' $R_t$ ' to collect the information from the environment. The collected information is transferred into the sink node in terms of data packets ' $P_j = P_1, P_2, \dots, P_m$ ' through the energy-efficient intermediate neighboring nodes ' $IN_1, IN_2, \dots, IN_n$ ' to extend the network lifetime and select route paths for routing.

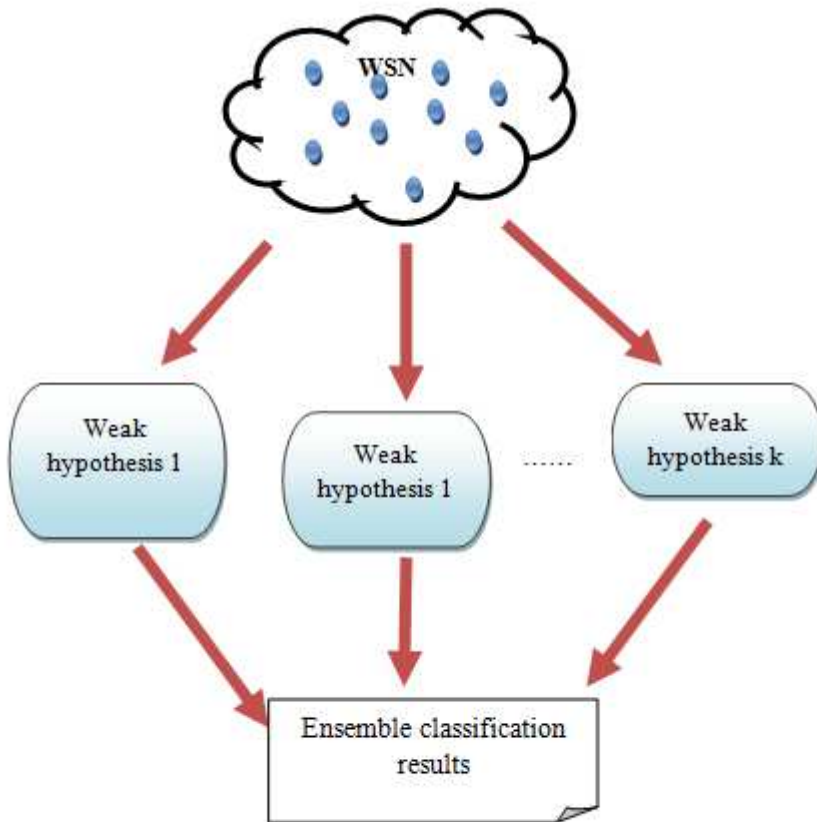


**Figure 1 architecture of MWIRMAB-RAR technique**

As given in the above figure 1, three different processes of the MWIRMAB-RAR technique are performed such as resource-efficient node selection, route path discovery, and data transmission. An elaborate description of the proposed MWIRMAB-RAR technique is provided in the forthcoming subsections.

### **3.1 Multivariate Weighted Isotonic Regressive Modest Adaptive Boosting**

The proposed MWIRMAB-RAR technique starts for detecting sensor nodes to improve network lifetime. MWIRMAB-RAR technique uses Multivariate Weighted Isotonic Regressive Modest Adaptive Boosting technique for identifying resource-efficient sensor nodes from network. The proposed Boosting technique is the ensemble classification technique which combines weak learners into strong learner. Weak learner is defined as classifier which is difficult to offer true classification. Strong learner is defined as classifier which offers well-correlated true classification results.



**Figure 2 schematic diagram of the Multivariate Weighted Isotonic Regressive Modest Adaptive Boosting**

Fig 2 illustrates Multivariate Weighted Isotonic Regressive Modest Adaptive Boosting algorithm. The ensemble boost technique considers the training samples as input i.e. number of sensor nodes. With training sensor nodes, empty set of weak learners  $Z_1, Z_2, Z_3, \dots, Z_k$  is constructed. Ensemble technique establish various weak learners as Multivariate Weighted Isotonic Regression to detect resource-efficient sensor nodes depend on energy and bandwidth,

The Multivariate Weighted Isotonic Regression is machine learning technique for detecting relationships between outcome variable and resources. Now, regression function determines resources of sensor node.

In WSN, energy is significant parameter for extending the network lifetime for each sensor node. At first, all the sensor nodes are distributed with a similar energy level. Due to the sensing and monitoring behaviors of the sensor nodes, the initial energy level is degraded. It is calculated below,



$$E_{node} = p * t \quad (1)$$

In equation (1),  $E_{node}$  specifies energy of sensor nodes,  $p$  indicates power, and  $t$  stands for time. Energy of each sensor node is estimated in joule (J). In WSN, Energy level of sensor gets corrupted through sensing process. It is calculated by,

$$RE_{NS} = T_{NS} - C_{NS} \quad (2)$$

Where,  $RE_{NS}$  denotes residual energy of sensor node,  $T_{NS}$  is the total energy of sensor nodes,  $C_{NS}$  represents consumed energy of sensor node. The bandwidth consumption is measured as the amount of data transmitted over a particular time.

$$bw = \frac{\text{Amount of } dp \text{ transmitted}}{t} \quad (3)$$

Where  $bw$  denotes a Bandwidth,  $t$  indicates a time,  $dp$  indicates a data packet. The bandwidth is calculated in bits per second. After the measurement of energy and bandwidth, the Multivariate Weighted Isotonic Regression is applied for classifying the sensor nodes. Here the multivariate represents the two objective functions such as higher residual energy and higher bandwidth. Weighted Isotonic Regression is used to estimate the variance between the objective functions and the sensor nodes.

$$Y = \sum_{i=1}^n \alpha_i \|NS_i - f(NS)\|^2 \quad (4)$$

Where,  $Y$  denotes weak classification results,  $\alpha_i$  denotes a weight,  $NS_i$  denotes a sensor node,  $f(NS)$  indicates an objective function of the sensor nodes. The node which is closer to the objective function is classified as resource-efficient sensor nodes. Otherwise, the sensor nodes are classified as normal nodes. But weak learner has some training errors. Therefore, the ensemble technique accurately classifies the sensor nodes through integrating weak learner's results. Ensemble classification results are obtained as given below,

$$Q = \sum_{j=1}^k Y_j \quad (5)$$

From (5),  $Q$  symbolizes the output of the ensemble weak learner,  $Y_j$  specifies classification results of weak learners. For each weak learner's results, the weight gets initialized for identifying the strong classification results. The strong classification output of weak learners is estimated as given below,

$$Q = \sum_{j=1}^k Y_j * \delta \quad (6)$$

After the initialization, the generalization error of a weak learner is estimated to show how accurately an algorithm is able to provide outcome values. The error is measured for each weak learner as given below,

$$E = \sum_{i=1}^n (Q_i - Q_a)^2 \quad (7)$$

Where,  $E$  denotes a generalization error,  $Q_i$  denotes actual outcomes of the weak learner results,  $Q_a$  symbolizes the observed classification of weak learner results. Behind classification results, initial weight is efficient. Update weights of the classification results increases, if classified wrongly by this classifier. Otherwise, the weights of the classification results get decreased. The gradient steepest descent function finds the weak classification results with minimum generalization error.

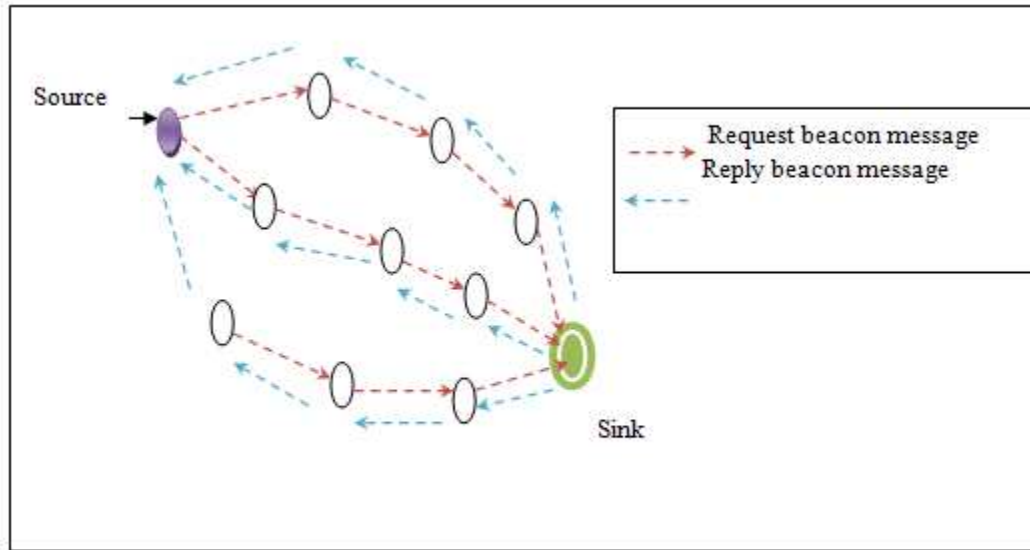
$$F = \arg \min E (Y_j) \quad (8)$$

Where,  $F$  denotes a gradient steepest descent function,  $\arg \min$  denotes an argument of the minimum function,  $E (Y_j)$  denotes an error of weak learner results. Based on classification results, the resource-efficient sensor nodes are correctly classified.

### 3.2 Route path discovery

Behind finding resource-efficient sensor nodes, multiple routes are established among source nodes and sink node. Route path discovery is performed by finding nearest neighboring node via beacon message allocation. Time of flight method is applied for measuring the distance between a sensor and a neighboring node through the beacon message distribution.

At first, source node sends beacon message to other resource-efficient sensor nodes in the network. Then the neighboring node sends reply message to source node.



**Figure 3 route path discovery**

Figure 3 illustrates multiple route path discovery among source and sink node to route data packets. At first, source node send request beacon message to other sensor nodes in network. After receiving the request beacon message, the reply is sent to source node. Based on message arrival time, the nearest neighboring nodes are correctly identified. Therefore, the time of flight is applied as given below

$$D_r = t_{BMA} - t_{BMT} \quad (9)$$

Where,  $D_r$  denotes distance,  $t_{BMA}$  indicates time of request beacon message arrival,  $t_{BMT}$  denotes time of request beacon message transmitted. Node that sends reply message and lesser time is selected as nearest neighboring node. The route path with lesser distance and minimum hop is selected for efficient data delivery. Algorithmic process of MWIRMAB-RAR technique is described as given below.

// Algorithm 1: Multivariate Weighted Isotonic Regressive Modest Adaptive Boosting based Resource Aware Routing
<b>Input:</b> $S_i = NS_1, NS_2, NS_3 \dots NS_n, P_j = P_1, P_2, \dots, P_m$
<b>Output:</b> Increase the data delivery
<b>Begin</b> <b>Step 1:</b> For each sensor node $NS$ <b>Step 2:</b> Construct 'k' number of weak learners <b>Step 3:</b> Measure energy, bandwidth <b>Step 4:</b> Apply regression $Y = \sum_{i=1}^k \alpha_i \ NS_i - f(NS)\ ^2$ <b>Step 5:</b> if $\arg \min \sum_{i=1}^k \alpha_i \ NS_i - f(NS)\ ^2$ then <b>Step 6:</b> Classify the sensor nodes as resource-efficient <b>Step 7:</b> else <b>Step 8:</b> Classify the sensor nodes as normal <b>Step 9:</b> end if <b>Step 10:</b> end if <b>Step 11:</b> Combine all weak learner results $Q = \sum_{j=1}^k Y_j$ <b>Step 12:</b> for each weak learner results ' $Y_j$ ' <b>Step 13:</b> Assign the weight ' $\delta$ ' <b>Step 14:</b> Discover the weak learner with $\arg \min E(Y_j)$ <b>Step 15:</b> end for <b>Step 16:</b> Return (strong classification results) <b>Step 17:</b> $S_n$ sends the request beacon message <b>Step 18:</b> Measure time of flight ' $D_r$ ' <b>Step 17:</b> Create multiple route paths <b>Step 18:</b> Find route path with minimum distance <b>Step 19:</b> Deliver the data packets to the sink node <b>Step 20:</b> Obtain efficient data delivery <b>end</b>

Algorithm 1 explains process of resource-aware routing in WSN. The proposed technique uses the ensemble classification technique for identifying the resource-efficient sensor nodes. The ensemble technique constructs the number of weak learners. For each sensor node, the energy consumption and bandwidth are measured. Then the regression is applied for measuring the relationship between the sensor nodes and the objective function. The node which is closer to the objective function is classified as resource-efficient sensor nodes. The weak classifications results are summed in to make a strong one. After integrating weak learner, weight is initialized. Followed by, generalization error is expressed for every weak learner. Depend on error value, initial weight gets efficient. Finally, gradient steepest function is applied for finding weak learner results with lesser error. After finding resource-efficient sensor nodes, multiple route paths among source and destination are recognized via time of flight method. Finally, the source node performs efficient data transmission with minimum delay.

#### 4. SIMULATION SCENARIO

The simulation of the MWIRMAB-RAR method and existing methods namely E3AF [1] EERH [2] are developed using NS2.34 simulator. In WSN, 500 sensor nodes are deployed in squared area(1100 m \* 1100 m). Random Waypoint model is used as mobility model. Sensor nodes are moved in network with a speed of 0 to 20m/sec. Time is 300 sec. In WSN, DSR protocol is used for resource-efficient routing. Table I shows simulation parameters are listed.

**Table I Simulation parameters settings**

Simulation parameters	Values
Network Simulator	NS2.34
Simulation area	1100 m * 1100 m
Number of sensor nodes	50,100,150,200,250,300,350,400,450,500
Number of data packets	50,100,150,200,250,300,350,400,450,500
Mobility model	Random Waypoint model
Nodes speed	0 - 20 m/s
Simulation time	300sec
Routing Protocol	DSR
Number of runs	10

#### 5. PERFORMANCE ANALYSIS

The proposed MWIRMAB-RAR technique and existing methods E3AF [1] EERH [2] were discussed with different performance metrics. The performance of different metrics is evaluated with table and graphical representation to determine the network scalability through varying sensor nodes.

- **Energy consumption:** It is significant metric to extend network lifetime. It is calculated as amount of energy consumed by sensor nodes to deliver data. It is formulated as follows,

$$Comp_{ER} = \sum_{i=1}^n NS_i * Comp_{ER} (SN) \quad (10)$$

Where,  $Comp_{ER}$  represents energy consumption,  $NS_i$  indicates number of sensor nodes,  $SN'$  denotes single sensor nodes. It is measured in joule (J).

- **Packet delivery ratio:** It is a major routing metric used to demonstrate proposed MWIRMAB-RAR method. It is measured as proportion of amount of packets that are effectively received at sink node to entire amount of packets sent. Therefore, overall delivery ratio is measured by,

$$DP_r = \left[ \frac{NPD}{NPS} \right] * 100 \quad (11)$$

Where,  $DP_r$  denotes packet delivery ratio,  $NPD$  indicates amount of packets delivered,  $NPS$  denotes amount of packet sent. It is calculated in percentage (%).

- **Packet loss rate:** It is another routing metrics that are measured as proportion of packets that are lost at sink node to entire number of packets sent. It is estimated as given below,

$$DP_L = \left[ \frac{NPL}{NPS} \right] * 100 \quad (12)$$

Where,  $DP_L$  denotes a packet loss rate,  $NPL$  denotes the number of packets lost,  $NPS$  denotes number of packet sent. It is measured in percentage (%).

- **End-to-end delay:** It is calculated as difference among expected arrival time of data and actual arrival time of packet at sink node. Delay of data delivery from source to sink is calculated as given below,

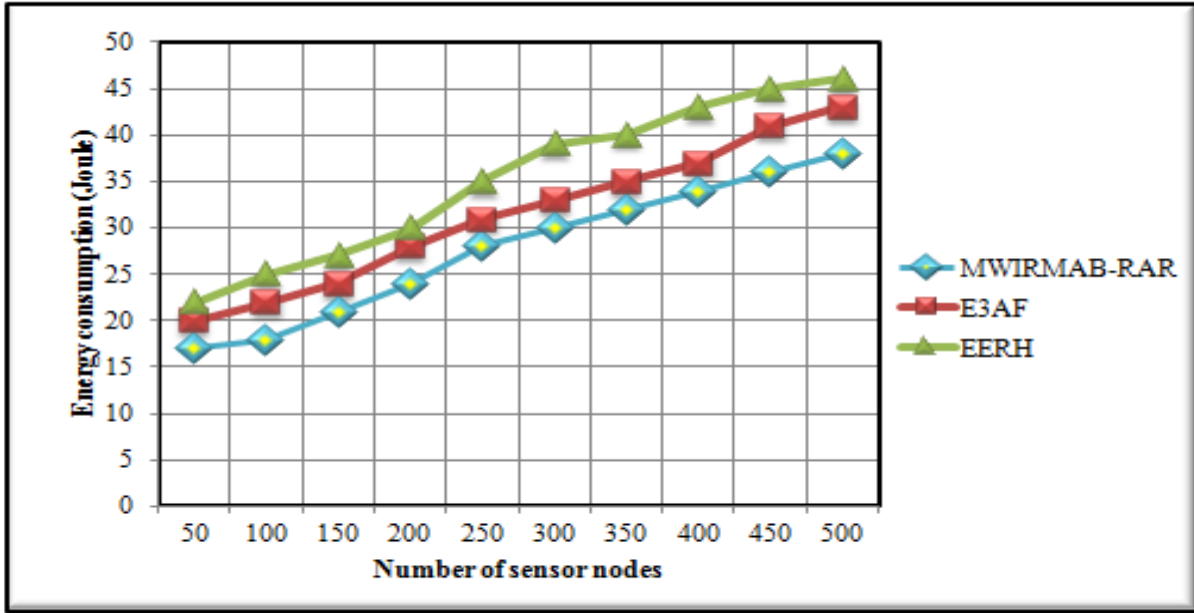
$$ED = [t_{Ex}] - [t_{act}] \quad (13)$$

From, 'ED' indicates end to end delay,  $t_{act}$  designates an actual packet arrival time and ' $t_{Ex}$ ' indicates expected arrival time. It is measured in milliseconds (ms).

**Table II Comparative analysis of Energy consumption**

Number of sensor nodes	Energy consumption (Joule)		
	MWIRMAB-RAR	E3AF	EERH
50	17	20	22
100	18	22	25
150	21	24	27
200	24	28	30
250	28	31	35
300	30	33	39
350	32	35	40
400	34	37	43
450	36	41	45
500	38	43	46

Table II indicates the simulation analysis of energy consumption with amount of mobile nodes. The amount of mobile nodes is taken in the ranges from 50,100,150,200...500 for ten iterations with three different routing methods MWIRMAB-RAR technique and existing methods E3AF [1], EERH [2]. For each routing technique, ten different results are observed. The obtained results indicate that the MWIRMAB-RAR technique provides superior performance than the existing methods. Let us consider 50 sensor nodes for performing simulation. The energy consumption of the MWIRMAB-RAR technique was observed 17 *Joule* and the performances of energy consumption are observed using E3AF [1] EERH [2] are 20 *Joule*, 22 *Joule* respectively. For each routing technique, ten different results are observed. The performance outcomes of energy consumption of the MWIRMAB-RAR technique are compared to existing methods. The comparison of ten outcomes indicates that the energy consumption of the proposed MWIRMAB-RAR method is significantly reduced by 12% compared with E3AF [1] and 21% compared with EERH [2].



**Figure 4 energy consumption comparisons with varying unber of sensor nodes**

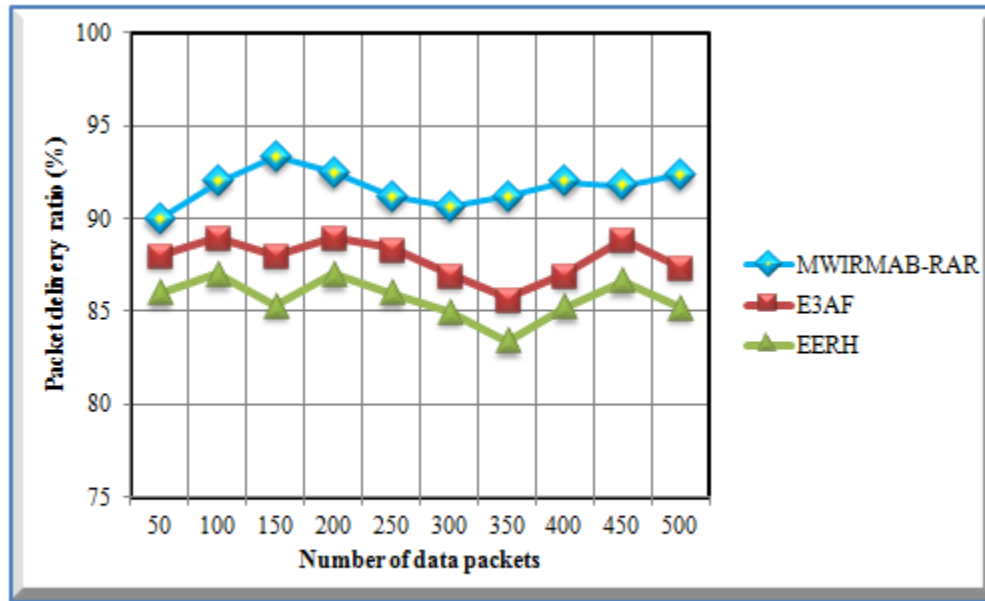
Figure 4 illustrates energy consumption with amount of sensor nods. From Figure 4, amount of sensor nodes (along y-axis) and energy consumption in terms of joule (along with the y-axis) are related to the extent of the network of the WSN. The observed results indicate that the energy consumption for all the methods gets increased. But comparatively, MWIRMAB-RAR technique outperforms well than other routing scheme. This improvement is archived through the application of finding the resource-efficient sensor nodes for data delivery. Resource-efficient sensor nodes are identified through the Multivariate Weighted Isotonic Regressive Modest Adaptive Boosting. The ensemble method is employed for finding better energy-efficient nodes for transmitting data. As a result, the overall energy consumption of the MWIRMAB-RAR technique is minimized than the existing methods.



**Table III Comparative analysis of Energy consumption**

Number of data packets	Packet delivery ratio (%)		
	MWIRMAB-RAR	E3AF	EERH
50	90	88	86
100	92	89	87
150	93.33	88	85.33
200	92.5	89	87
250	91.2	88.4	86
300	90.66	87	85
350	91.14	85.71	83.42
400	92	87	85.25
450	91.77	88.88	86.66
500	92.4	87.4	85.2

Table III reports the performance results of packet delivery ratio versus amount of packets being sent. The number of data are considered for simulation is varied from 50,100 ...500. The table value indicates that the performance of packet delivery ratio of three routing techniques MWIRMAB-RAR technique, E3AF [1], EERH [2] is obtained. Among three methods, MWIRMAB-RAR technique outperforms well in achieving high data delivery. With consideration of 50 data packets being sent, amount of successful packets is sent at destination is 45 and packet delivery ratio of the MWIRMAB-RAR technique is 90%. Similarly, the packet delivery ratio of E3AF [1], EERH [2] are 88%, 86% respectively. Followed by, nine results are obtained for each routing technique. The observed performance results of the MWIRMAB-RAR technique are compared to existing methods. The average of ten comparison results is taken into consideration of final results. The comparison results provide the overall packet delivery ratio of the MWIRMAB-RAR technique is considerably increased by 4% and 7% than the existing [1] [2].



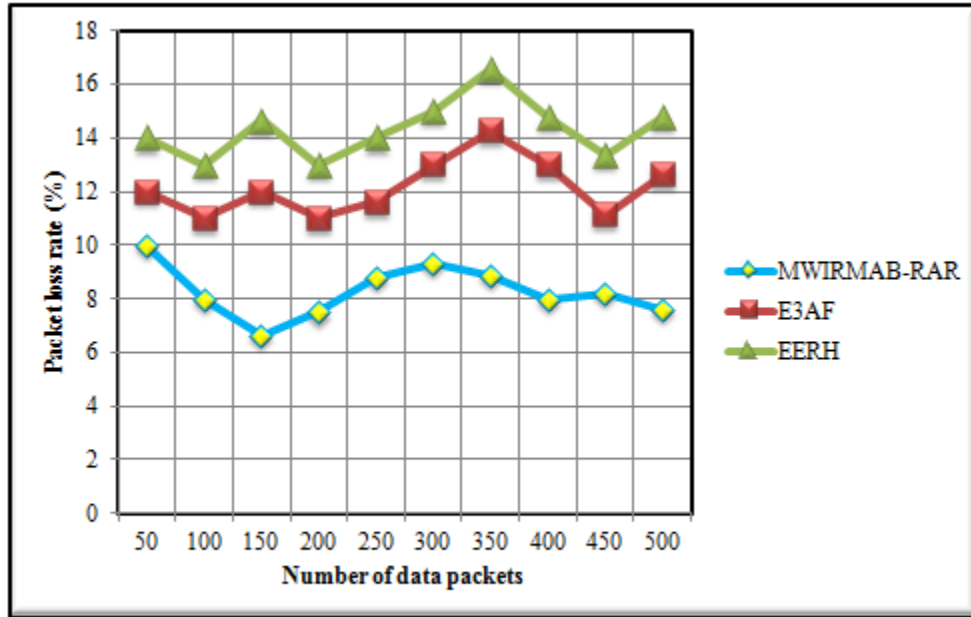
**Figure 5 packet delivery ratio comparisons with varying number of data packets**

Fig 5 explains packet delivery ratio of three routing techniques. The packet delivery ratio of y-axis is represented with amount of data packets on x-axis. As shown in figure 5, the delivery ratio of three different methods MWIRMAB-RAR technique, E3AF [1] EERH [2] are represented by three different colors namely blue, red and green. The graphical plot indicates that the MWIRMAB-RAR technique provides superior performance than the other two methods. This is because the MWIRMAB-RAR technique finds resource-efficient nodes for the routing process. The higher energy efficient nodes and higher bandwidth increase the data transmission. As a result, successful data delivery ratio is obtained at the sink node.

**Table IV Comparative analysis of packet loss rate**

Number of data packets	Packet loss rate (%)		
	MWIRMAB-RAR	E3AF	EERH
50	10	12	14
100	8	11	13
150	6.66	12	14.66
200	7.5	11	13
250	8.8	11.6	14
300	9.33	13	15
350	8.85	14.28	16.57
400	8	13	14.75
450	8.22	11.11	13.33
500	7.6	12.6	14.8

The comparative result analysis of packet loss rate is depicted in Table IV. The MWIRMAB-RAR technique is implemented in the NS2 simulator with a varied number of data packets in the range of 50-500 for calculating packet loss rate. When conducting the simulation with 50 data packets in the first iteration, the proposed MWIRMAB-RAR technique lost 5 data packets whereas E3AF [1] EERH [2] lost 6 and 7 data packets respectively. As a result, the packet loss rate of the MWIRMAB-RAR technique is 10% and the loss rate of existing [1] [2] is 12% and 14% respectively. The proposed technique is compared with existing methods. The overall comparison results indicate that the performance of the packet loss rate of the MWIRMAB-RAR method is decreased as 31% compared with E3AF [1] and 42% compared with EERH [2].

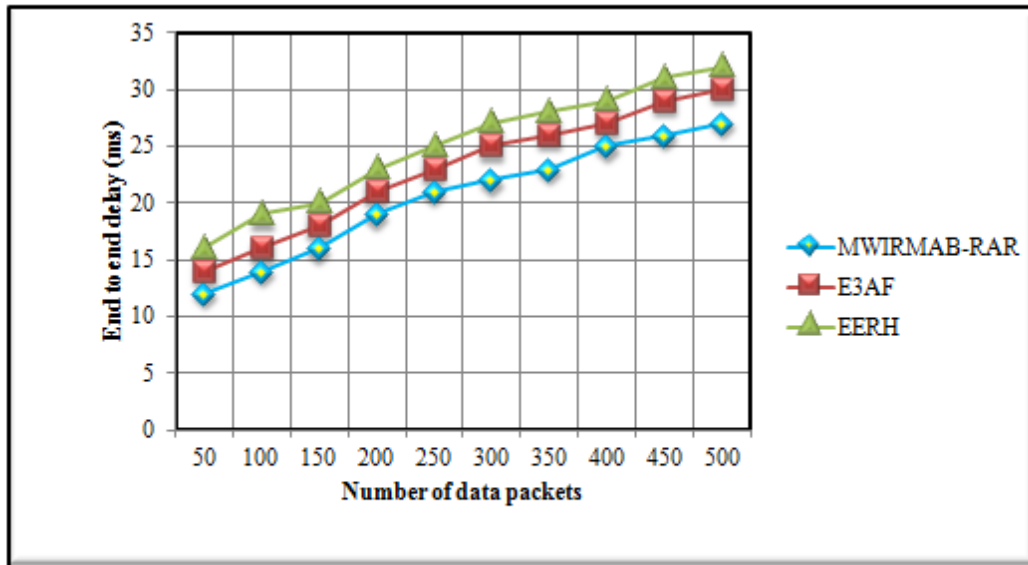


**Figure 6 packet loss rate comparisons with varying number of data packets**

Fig 6 presents the impact of packet loss rate with diverse amount of data with proposed and two existing methods. The graphical diagram shows MWIRMAB-RAR method decreases the packet loss rate than the other two conventional routing schemes. This is because the application of the node which has better bandwidth and higher energy efficiency is selected to route data. This minimize data loss and increase data delivery.

**Table V Comparative analysis of End to end delay**

Number of data packets	End to end delay (ms)		
	MWIRMAB-RAR	E3AF	EERH
50	12	14	16
100	14	16	19
150	16	18	20
200	19	21	23
250	21	23	25
300	22	25	27
350	23	26	28
400	25	27	29
450	26	29	31
500	27	30	32



**Figure 5 end to end delay comparisons with varying number of data packets**

Table V and Figure 5 presents delay along with diverse number of packets using three methods. The graphical result of proposed MWIRMAB-RAR method offers lesser amount of delay in order to accurately perform the data transmission when compared to conventional E3AF [1] EERH [2]. Let us consider '50' data sent, delay of MWIRMAB-RAR technique was found to be '12ms', and the delay of existing E3AF [1] EERH [2] is '14ms' and '16ms' respectively. The above estimated mathematical result

confirms that the MWIRMAB-RAR technique outperforms well in minimizing delay. The overall assessment of ten outcomes confirms delay for deliver data is decreased as 11% compared with [1] and 19% compared with [2] respectively. The main motivation of enhancement is used to find energy and bandwidth. In addition, MWIRMAB-RAR technique finds nearest neighboring node via a time of flight method. Then the MWIRMAB-RAR technique discovers the route path with minimum distance for enhancing data delivery and reduces delay.

## **6. CONCLUSION**

This paper innovatively applies the new technique called MWIRMAB-RAR is introduced for enhancing energy and reliability of WSN. The MWIRMAB-RAR technique finds the resource-efficient sensor nodes by applying the Modest Adaptive Boosting technique. The ensemble technique uses the weak classifier for finding the efficient sensor nodes based on energy and bandwidth. After selecting the resource-efficient sensor node, the route paths are constructed based on the time of flight method for identifying the neighboring sensor node. Finally, the data transmission is performed through the resource-efficient nodes. This increases data delivery and decreases the packet loss and delay. The simulation investigation is carried out on certain performance factors. The proposed MWIRMAB-RAR method offers high delivery rate, and decreases loss rate, delay, and decreases consumption of energy than conventional methods.

### **Compliance with ethical standards**

**Conflict of interest** The authors have no conflicts of interest to declare that are relevant to the content of this article.

### **Ethical approval**

This article does not contain any studies with animals performed by any of the authors.

### **Authorship contributions**

All authors are equally contributed

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