A Novel Mixed Routing Methodology (MRM) For Heterogeneous Sensor Network Using Machine Learning

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Abstract:

For the management, operation, and optimization of smart networks, computational intelligence methods are desirable. In wireless sensor networks (WSNs), adding more nodes necessitates the seamless delivery of large amounts of data to different nodes. These high data transfer rates may cause wireless sensor networks to be overloaded, which provokes congestion, latency, and packet drop. In addition to causing information loss in wireless sensor networks, congestion also costs a lot. An effective computational intelligence strategy Mixed Routing Methodology (MRM) for improving data transfer while reducing latency is required to address this challenge is proposed. This schema able to route data packets by avoiding busy data path and selecting sensor nodes with maximum energy back up and lower data load. The proposed schema has two steps: Data route Formation and Data congestion-aware routing. Before to constructing the data routing, the residual energy of the sensor node is calculated. Then, the residual energy level is analyzed using regression manipulation to find whether or not the sensor node have sufficient energy backup.The energy-efficient nodal points are geographically positioned, and Multiple data paths between the source and sink sensor nodes will be Routed using route request and route reply. After that, congestion-aware routing based on buffer space and bandwidth capacity is performed using the MRM approach. Out of all possible routes, the one with the maximum bandwidth capacity and the least amount of buffer space is chosen as the best route. To minimize data latency and data loss along the data route path, congestion-aware data transmission is implemented. In relation to the quantity of data packets and sensor nodes, the simulation takes into account a number of performance parameters, including energy consumption, data delivery rate, data loss rate, throughput, and delay.

Keywords: *machne learning, heterogenous sensor network, routing.,*

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Introduction:

In WSN, the condition of the environment is monitored, recorded, and transmitted to the base station with the use of wireless sensor networks (WSNs). To execute effective communication between the several networks, the network-on-chip (NoC) architecture was developed. In order to reduce latency, the developed system utilized on-chip antennas between long-distance cores. However, network-on-chip (NoC) architecture did not increase energy efficiency.

Some of the ad-hoc networks based on wireless connectivity, opportunistic routing for MIMO was defined in [1-2]. (WANETs). Opportunistic routing did not help to lower the delay. In [3], a model for congestion-aware routing algorithm that separates the network-on-chip (NoC) into several subnets was described. But congestion routing aware approaches may not minimize the computational complexity.

For the purpose of learning the residual network resources for multicast classification tasks, a new functional gradient boosting was presented in [4]. However, functional gradient boosting had little effect on the packet delivery ratio. RBoost1 and RBoost2, two data noise

resistant boosting algorithms, were introduced in [5]. It did not concentrate on samples to the base stations incorrectly.

To reduce the data congestion, a routing approach was created in [8]. The approach did not provide an efficient routing scheme, it only communicated the weights computed from congestion-related factors to neighboring network modules. Congestion avoiding to enhance network The Lifetime Protocol was created in [9] with the goal of extending network lifetime for decreasing data congestion. The computational complexity was not, lessened.

High computation complexity, reduced energy efficiency, shorter network lifetime, slower data delivery rate, computational complexity, higher packet loss rate, higher latency, etc. are some of the problems mentioned in the above literature. A congestion-aware routing approach proposed Mixed Routing Methodology (MRM) for reliable and congestion routing awareness in WSNs is created to address these challenges.

The important contribution by proposed schema are as follows,

1) The fundamental goal of the MRM approach is to route data packets avoiding congested locations to identify the energy-efficient and load balance nodes by using Machine learning techniques two procedures are included in the MRM method: data route path construction and data congestion aware routing. For the purpose of identifying the efficient data flow path, the node's residual energy is calculated.

2) Regression analysis used at the residual energy level determination to find whether the node is an energy-efficient node or not. With the aid of route request and route reply, the energy-efficient nodes are found and built via the various paths from source node to sink node.

3) The best route path among the available options is chosen as it uses less buffer space and has a greater bandwidth capacity. Finally, route path congestion-aware data delivery is used to reduce data latency and packet loss.

The remaining part of the paper is formulated as follows: Section 2 describes an overview of the related works of congestion routing aware in WSNs. Section 3 gives a brief explanation of the proposed MRM schema with neat diagram. In Section 4, simulation settings and the corresponding result analysis are discussed. Finally conclusion misgiven in Section 5.

2. Overview of Related works

For data rate optimization, a multi-objective optimization algorithm called was introduced in [11]. It is a congestion control algorithm. The congestion control mechanism did not improve the network lifetime. For improving the reliability performance, a congestion-based, reliable procedure was presented in [12]. The protocol's ideal solution technique, called Order Preference by Similarity, is used to find the best path for transmitting data packets. However this, Reliable and congestion-based protocols did not reduce the computing cost.

To reduce the negative impacts of network congestion, a congestion management data routing protocol based on a centralized method was presented in [13]. There was no reduction of the computational complexity. To enhance the performance of the congestion control algorithm from [13], an enhanced version was defined in [14]. Even if congestion control was implemented, energy efficiency did not increase.

In [15], a congestion control technique based on fuzzy logic was developed for WSN. However, the rate of packet loss did not go down. In [16] proposed a congestion control technique based on optimum rate for transmissions that use less energy. Even though energy efficiency increased, the congestion control system did not minimize routing overhead.

To improve network speed, an effective congestion avoidance method using the Huffman coding algorithm was introduced in [17]. The alternate paths with the least amount of congestion were found using an ant colony optimization. However, the congestion avoidance strategy did not minimize the amount of network complexity.

For queue management, a dynamic technique was developed in [18] to quickly identify the congestion and avoid collisions. Depending on queue quality, the back-pressure strategy was used to reduce the likelihood of connecting in the pathway. The dynamic technique did not reduce data delay.

3. Proposed Mixed Routing Methodology (MRM).

A wireless sensor network (WSN) is a collection of sensor nodes that can transmit sensed data's either to a sink node or to any of its nearby nodes. MIMO technology is a type of wireless communication that transmits multiple data signals simultaneously. Usage of MIMO technique is crucial for 3G, 4G, and 4G LTE networks. WSN has faced a variety of challenges, including data congestion issues that affect network bandwidth utilization and regularly changing network topology.

The Network load balancing in WSN is equivalent to the congestion avoidance. The excessive traffic distribution is impacted on the usage of a potential congestion avoidance algorithm. As a result, a new strategy is needed to improve data delivery and reduce latency. The MRM approach, a dependable and Congestion-aware routing strategy, is proposed in this paper to route packets away from congested locations by locating the nodes that are energy-efficient and minimum utilization in the network. Constructing an energy-efficient path identification and congestion-aware routing in parallel is the main idea behind the MRM approach.

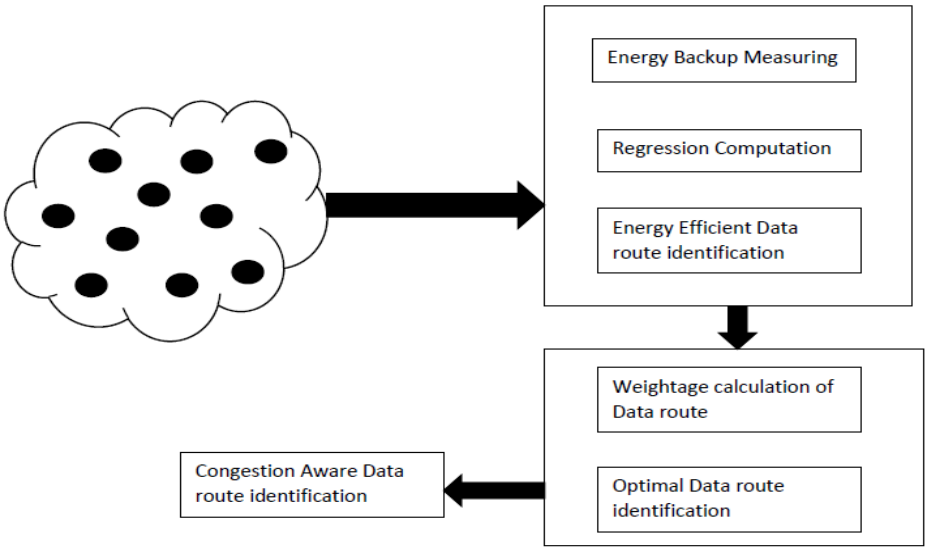

Figure 1: Structural design of the proposed MRM method.

The suggested MRM method's structural layout for MIMO routing and route path identification in wireless technology is shown in Figure 1. Every distributed sensor node's energy is calculated using the proposed method. After that, by sending the request and reply messages, the route path between the source and destination is discovered. To ensure efficient data routing, the shortest path is used. Congestion-aware routing module is used in data transfer to reduce network congestion with the least amount of latency.

3.1 Network Formation

A sensor network structure is formulated by distribution of sensor nodes as "$N_1, N_2 \ldots\ldots N_n$" in a transmission range represented as "T_r". The sensor nodes are formed as a squared area having a dimension of " $n * n$ " which has capability of collecting the data's from the environment. The sensed data packets from the sensor nodes as " $D_1, D_2 \ldots D_n$" are transmitted to the destination node "N_d" through the neighboring nodes " $NB_1, NB_2 \ldots NB_n$ " used for avoiding the data congestion in the data transmission. This is data transmission is efficiently carried through neighboring nodes having maximum residual energy and minimum data load.

3.2 Regression Computation for Efficient Data Route identification

The MRM approach uses regression analysis to determine data route identification

among sensor nodes. Finding the relationship between the dependent variable in the network parameters (i.e., "outcomes") and independent network parameters is done using analysis based on machine learning schema (i.e., features). The energy of all the sensor nodes is observed using regression analysis. All sensor nodes have a same energy level at the starting time of implementation, and this energy level may minimized when sensing process get started. Depending on the data packets sent through a nodal point, the energy back up will change. The product of power and time will be used to calculate the energy backup. The relationship is given by equation 3.1

$$E_n = Pwr * T_n \qquad (3.1)$$

In the above relation (3.1) E_n represents energy backup of sensor nodes measured in *joules*, *Pwr* is the power and it is given *watts, T n* is the time span given in *seconds.* We know that the energy backup will vary on the nodes will which is depending on the sensing operation carried by the corresponding nodes. It is given by equation (3.2) as below,

$$E_{res} = E_{total} - E_{consumed} \qquad (3.2)$$

Where E_{res} gives residual energy, E_{total} represents total energy at the time of implementation of the sensor node , $E_{consumed}$ shows the energy used for the sensing and forwarding of the data packets through the node. The MRM method's regression analysis looks at the expected node energy level and identifies the energy-efficient nodes for the data transmission. The logistic function defined is used to simplify the several dimensions of computation using regression analysis. It is used as an activation function to classify the sensor node output according to the probability distribution of the expected output classes. It is given as (3.3)

$$RA = e^{Xi} / \Sigma^{p}_{n=1} e^{xp} \qquad (3.3)$$

'Xi' depicts residual energy of the particular sensor node 'n' ranges from 0 to p. For the normal computation on regression, the output of the regression schema will be ranges from '0 to 1'. Depending on the regression output the energy efficient node will be chosen for data forward process. If regression gives the output ranges from '0 to 0.5', then the sensor node is categorized as *non efficient node*. When the regression analysis the output ranges from '0.5 to 1', then the sensor node is termed to be as *energy efficient node*. After the completion of regression analysis, the node with higher residual energy is selected for data route path construction. The Count of route is constructed between the source node and Sink node will be performed by two control messages like route request 'R_{req}' and route reply 'R_{rep}'. Then the source node Passes the request message to the destination node through the intermediate nodes. After the collection of all request message, sink node will reply to the source node.

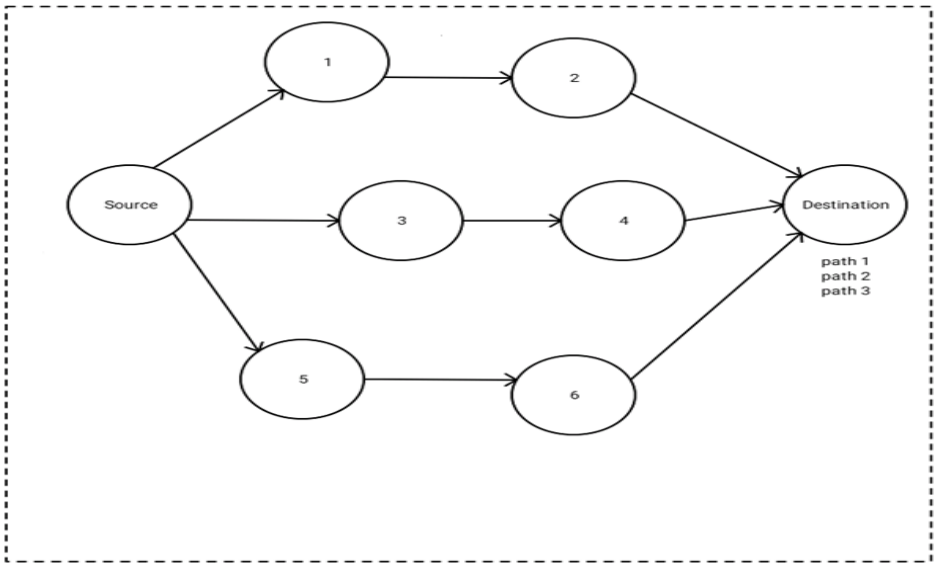

Figure 2: Route path construction

From the above figure 2, it is observed the availability of the data routes between the source and destination nodes. The available path and the data hop count is "2" for all of the path available. But the path which has low congestion s chosen using regression manipulation.

3.3. Data Route Classification On Congestion Awareness metrics

In machine learning schema, boosting is a process which merges the low learners to group the higher learners. As a result, MRM methodology works the reweight adaptive boosting classification algorithm to increase the classification performance on data route having low congestion. It uses the Tanimoto based function in the proposed MRM methodology for categorizing data route path as a congestion aware and non - congestion aware data route path. The flow mechanism of adaptive boosting is shown in Figure 3.

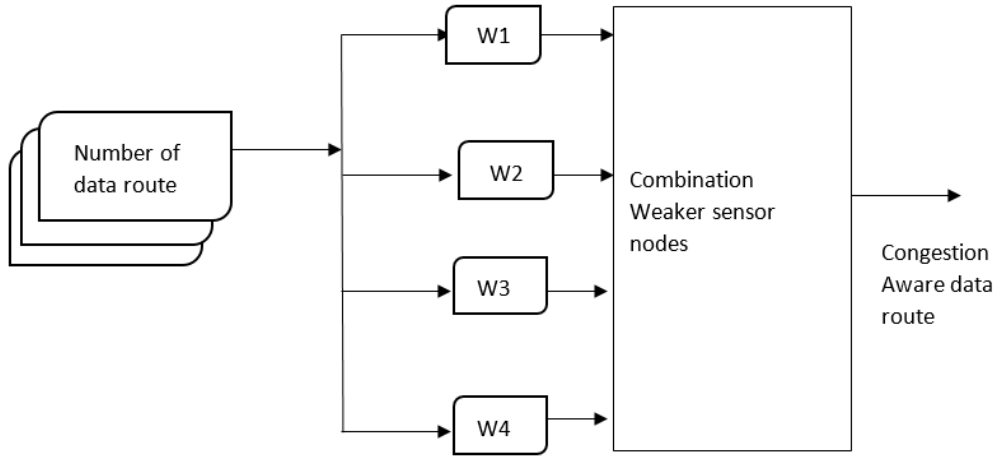

Figure 3: Format of adaptive boosting on congestion aware data Route.

The boosting enables MRM method to classify the data route into various classes on the basis of weightages. Assume that the training data for the Algorithm to be multiple data route *"R_1, R_2 and R_3"* as *"x1, x2 and x3"* represent the classified output. Also set of weak learners *{w1, w2, w3 }* created as training set for the input module and grouped to form the strong one. A decision step is the decision based tree where data route is classified based on the congestion Aware metrics. Tanimoto based correlation is used in MRM method to identify the relationship between congestion-free data route and Ongoing data route path. It is computed as follows:

$$\text{Tan}_{\text{correlation}} = A / B \qquad (3.4)$$

In the above relation A= (Data congestion − free route ∩ Ongoing Data route |)

B = {(|congestion − free route path|) + (|constructed route path| − |congestion − free route path ∩ constructed route path |)}

The above equation (6), shows the Tanimoto based correlation which produces the output value between 0 and 1. The threshold stage value of regression analysis will be set to the average of higher and lower value as zero and as 1 respectively. Hence, we set the threshold stage value as 0.5. When the correlation value ranges between'0 to 0.5'. It will be denoted as *non-congestion aware Data Route.* If the correlation value lies in the range '0.5 to 1', it is termed as *congestion aware Data Route*. On the Basis of the obtained correlation value, the decision step identifies the data route into two different classes as Stronger and Weaker. After classification, the weak

Learners are merged to form the strong learner set.

The *Algorithm 1* explains the regression process which uses Tanimoto based boosting for the identification of reliable energy backup and data congestion aware routing. For each and every sensor node in network, the residual energy back up is calculated. After, that using the regression

Function the estimated energy back up of sensor node is investigated for selecting *Energy Efficient Sensor Node*. On the basis of regression analysis, the energy-efficient sensor nodes will be selected for MIMO routing (Mixed Routing). Using the help of energy-efficient sensor nodes, many efficient data routes are identified between source and sink node. The multiple data route paths are rearranged by transmitting two control messages like R_{req} and R_{rep} from source to the destination. Finally, the congestion-free data transmission path is identified and an efficient data transmission is carried out with higher data delivery.

Algorithm 1: Regression based MRM routing strategy

Input: Sensor node "$N_1, N_2 \ldots\ldots N_n$" source node, destination Node.

Output: Identifying the Congestion Aware Data route.

1) For each of N_1, ,calculate the residual energy.
2) Manipulate the energy back up of nodes using regression process
3) If(RA<0.5), node is Energy Aware efficient Node
4) Else node is a non - efficient node.
5) End if.
6) End For.
7) Forming a data Route path between Source and destination Node.
8) N_n send R_{req} control messages to sink node.
9) After receiving the control message R_{rep} to source node.
10) For each of the constructed path, using Tanimoto based manipulation will be carried out.
11) Congestion Aware data route is identified by grouping weak nodes to a stronger group of nodes.
12) End for

End

4. SIMULATION SETTINGS AND RESULT ANALYSIS

The simulation results of MRM method and the performance is compared with existing methods is done. For the calculation of MRM methodology, we furnish the simulation, 100 sensor nodes are used. The proposed and previously defined method performance is determined. The performance analysis of the proposed MRM method and existing methods namely network-on-chip architecture and opportunistic routing are done with five different metrics, namely power efficiency, data delivery rate, end to end delay and data latency.

4.1 ENERGY EFFICIENCY

The energy is important for the data transmission in the sensor network. From figure 4 and table 1 we may depict the performance of MRM methodology.

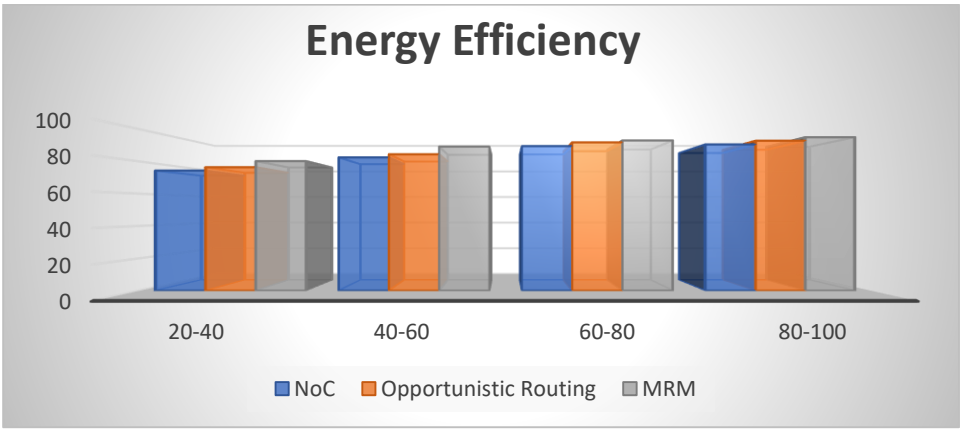

Figure 4. Energy Comparison

Nodes count	NoC	Opportunistic Routing	MRM
20-40	74.3	76.4	80.2
40-60	82.5	84.4	89.2
60-80	89.5	91.8	93
80-100	90.5	92.8	95

Table 1. Comparison of energy efficiency of various schema

4.2 Data delivery rate:

The successful transmission of data packets implies the system efficiency. For observing the proposed methodology data rate, we may see the performance from the Figure 5 and table 2.

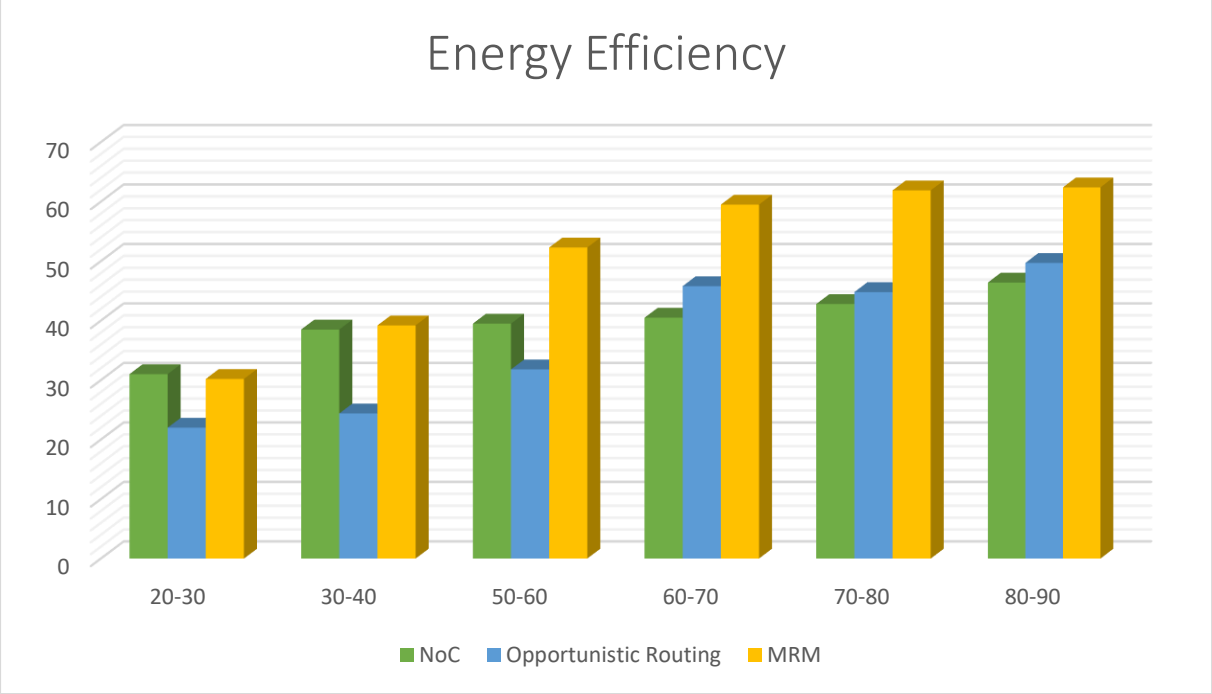

Figure 5. Comparison of data rate of various methodology

Table 2. Data Rate

Nodes count	NoC	Opportunistic Routing	MRM
20-30	31	22	30.2
30-40	38.5	24.4	39.2
50-60	39.5	31.8	52.3
60-70	40.5	45.8	59.5
70-80	42.8	44.8	61.9
80-90	46.4	49.7	62.4

Analysis of different methodology

4.3 Data Latency

In general, the delay in the data transmission between source and sink node should minimum. This is because when it is low losses in data packets is minimum. Hence system efficiency will be increased. The performance in data latency of proposed methodology is depicted in Figure 6 and in table 3.

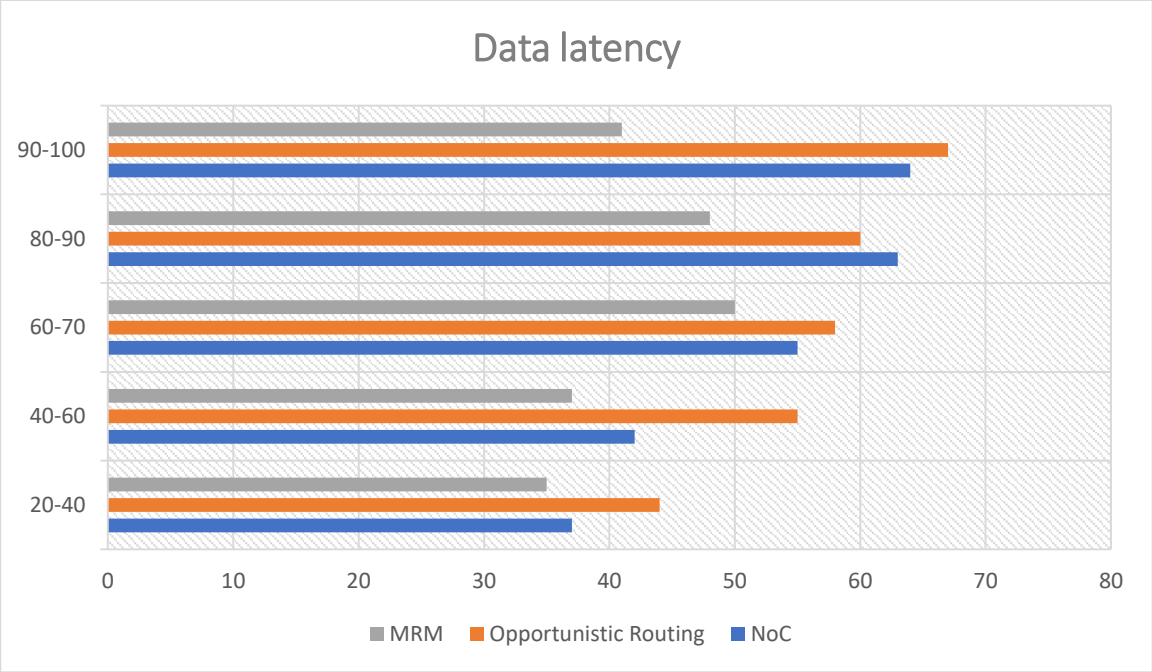

Figure 6 Comparison of Data latency

Nodes count	NoC	Opportunistic Routing	MRM
20-40	37	44	35
40-60	42	55	37
60-70	55	58	50
80-90	63	60	48
90-100	64	67	41

Table 3 Details on data latency

4.4 End to End Delay.

The graph in Figure 7 illustrates the total end-to-end delay obtained by each algorithm regarding the total number of nodes with a comparison on table 4. The total end-to-end delay obtained by each algorithm is demonstrated in graphical view for comparison result and table with detail values. The performance obtained by the MRM is represented in the blue bar, DPPMSBT performance with pink bar and yellow bar describes the NOC performance. Both graphical and table views clearly show that the total end-to-end delay achieved by the proposed MRM is very minimal than the other algorithms.

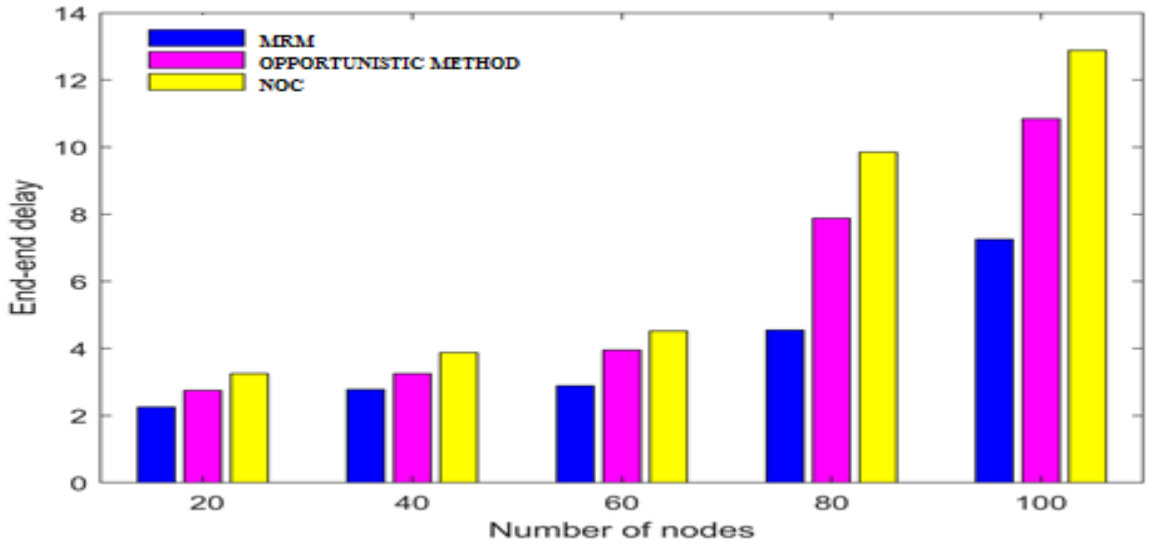

Figure 7. Number of nodes vs. end-end delay

Number of nodes	MRM (ms)	OPPORTUNISTIC ROUTING (ms)	NOC (ms)
20	2.25	2.75	3.25
40	2.78	3.25	3.88
60	2.89	3.95	4.52
80	4.55	7.88	9.85
100	7.25	10.85	12.88

Table 4 Number of nodes vs. end-end delay

5. CONCLUSION

A novel routing methodology given as MRM is presented on routing data packets in the congested sensor network by identifying the power efficient and minimum sensor nodes in a heterogeneous sensor network. MRM method have data route path creation and data congestion aware routing. The node's residual energy is initially calculated before the new data route to be created. This is done by using of regression analysis for residual power back up computation. The regression separate the energy efficient and non-energy efficient node on the basis of threshold value given in the regression function. Then the multiple path is created between the sources and sink nodes. After that Tanimoto based computation is performed for identifying congestion aware routes. It used to group weaker nodes to form a data path as a stronger one.

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