Energy Efficient Probabilistic MAC Protocol for Minimizing Node Search Space and Access Time in Dense Wireless Networks

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Abstract-The leading focus of Wireless multi-hop networks is to deliver internet access to its users anytime & anywhere. Medium Access Control mechanisms are needed to access the channel in contending wireless nodes. They make use the effective antenna technologies at physical layer to access the channel. Sensor Nodes deployed are battery operated, hence protocols designed for them, innately must be energy efficient. Also, depending on the application, reliability and latency might be important parameters. Due to the large number of sensor nodes, packet delivery to the sink node leads to increased traffic congestion. In this proposed model, we optimized these issues on static and dynamic multi-channel WSNs. The main objective of the proposed system is to improve the node energy efficiency and to minimize the access time of the dense area wireless networks.

Keywords: WSN, MAC, Energy Efficiency, Node Search Space, Access Time.

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I. INTRODUCTION (HEADING 1)

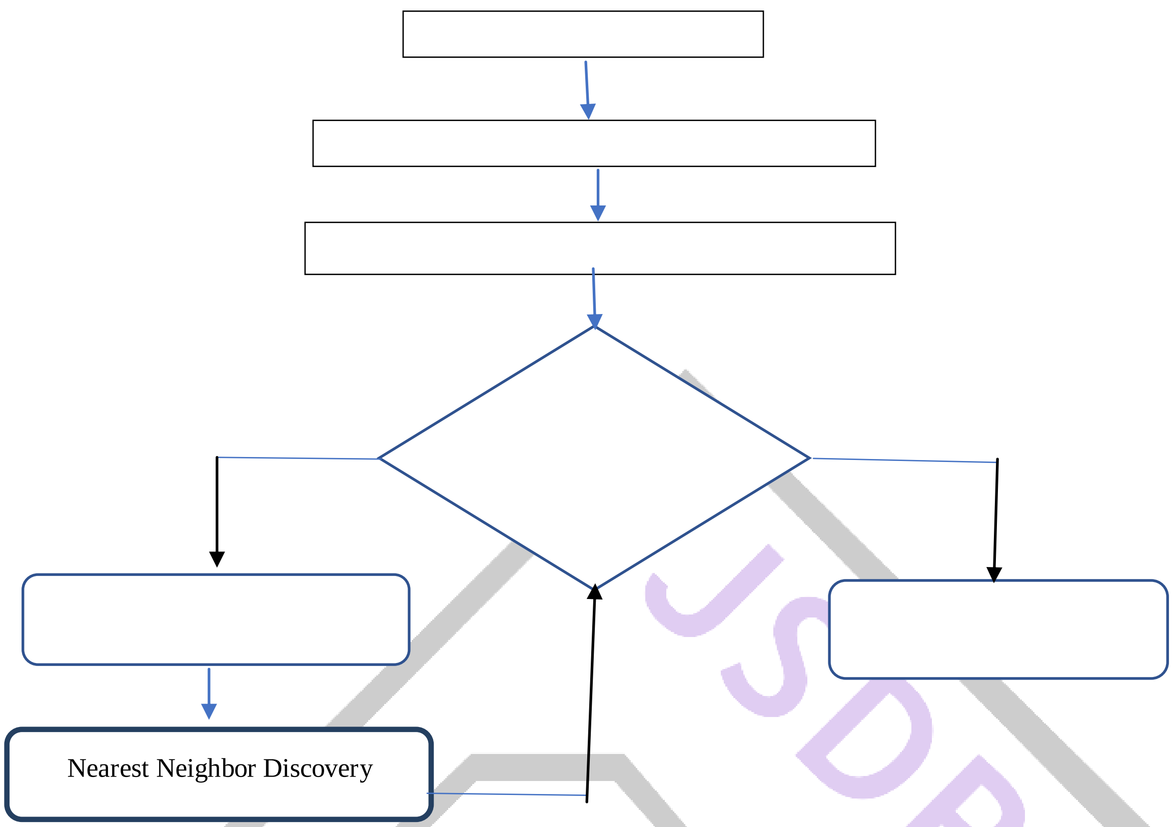
Wireless Sensor Networks (WSNs) consists more number of sensor nodes with limited power or battery supply, small size and very economical price that are deployed across interested focal area by forming correspondence multi hop network. These nodes will receive information based on sensor type, will process them and transmit it to the sink nodes that transmits it by the internet or other means to the control center for further decision making process. The nodes are arbitrarily placed and the Medium Access Control protocols in this regard should mainly focus on the properties viz. throughput, scalability and latency.

These sensor nodes can do the recording of physical states of the environment and also can measure natural conditions like temperature, light, sound, mugginess ...etc. as long as the device is active. Hence MAC protocols have to consider energy management and also has to ensure minimal wastage of energy in the system. In both event based and data stream based sensor networks for collecting and transmitting data, a data stream will be formed from the source node to the destination node and which may form a congestion in the network due to mismatch of sent and received data. The lost packets due to congestion should be re sent, which result in waste of energy and it reduces overall network lifetime, which is described as the time after end of life of first sensor.

Dense node mobility can lead to a distortion in the establishment of quality link. Also, frequent node link disconnection may lead to repeatedly establish new links, which increases node search space with the nearest neighbor nodes for data transfer. As a result of node search space, node collision and link failure, the overall network communication overhead will be increased. Due to the large number of sensor nodes, packet delivery to the sink node leads to increased traffic congestion. In this proposed model, we optimized these issues on static and dynamic multi-channel WSNs. The main objective of the proposed system is to improve the node energy efficiency and to minimize the access time of the dense area wireless networks.

II. ARCHITECTURE OF THE PROPOSED SYSTEM

EEPM-NSAD Framework



In this proposed system, each communication node chooses the nearest neighbor node in the dense networks or congested networks using the probabilistic measure and the next hop address of the source node. Each node in the dense network computes the decision parameters for data transfer and check the communication range of nearest neighbor nodes within the channel k. Here, each node transmits its data using link load and energy required to closest nodes over the selected communication channel when the network communication terminates due to node contention or access delay.

The probabilistic optimization function for the EEPM-NSAD is given as

$$\text{Min } \text{Energy}(\text{Dense}(\text{n}_i))/Cap^k{}_{(x,y)}, \text{DistNodes}(\text{n}_{i-1},\text{n}_i); \text{k}-W_{ch}(n_{i-1},n_i) \text{ ----(1)}$$

$$\text{DistNodes}(\text{n}_{i-1},\text{n}_i) = \sqrt{|X_n - X_{n-1}|^2 + |Y_n - Y_{n-1}|^2}$$

Let $prob^k{}_{ij}$ represents the probability of the node in the selected channel as link constraint.

$prob^k{}_{mn} = 1$, if the dense node m communicates with node n over selected k-channel.

= 0; otherwise

$$\text{Max } \{prob^k{}_{ij}, Cap^k{}_{(x,y)}\} \qquad \text{-------(1)}$$

$$\text{S.t } \sum prob^k{}_{ij} \le \lambda$$

Where λ represents the maximum number of nodes in the dense wireless area of the k-th communication channel.

Let $\text{Prob}^l_{i,j}$ denotes the probability of the node load estimation parameter for energy restriction over dense communicated areas.

The objective function of the node's load estimation is given as :

$$\text{Min Prob}_{i,j}^{l} = NN_l * \mathrm{N}_{ch} / N_{IR} \quad (2)$$

NN_l :Number of nearest neighbor nodes with the high load capacity

N_{ch} : Channel capacity

N_{IR} : Number of links in the dense network area.

III. Node Energyand Load Optimization Functions:

Energy based link load estimation is the computational sum of the node broadcasting data rates and energy consumption of the selected link per unit time in the dense networks. The energy efficient link load parameter on each communication path is given as

$$EL^{*}_{(\mathrm{i,j},k)} = w_{l(i,j)} * \mathrm{NN}_{l(\mathrm{i,j},k)} + \lambda_e * \mathrm{NN}_{E(\mathrm{i,j},k)}$$

$$0 \le \lambda_l \le 1$$

$w_{l(i,j)}$: weight of the link nodes in the requested path i to j.

$\mathrm{NN}_{l(\mathrm{i,j},k)}$ is the nearest neighbor link load of the path over kth channel.

The main constraint in the dense network is to minimize the dense node collisions to avoid termination problem.

$$\text{Min} \sum EL^{*}_{(\mathrm{i,j},k)} / N_{ch} < 1 \text{---------}(3)$$

$$\text{s.t} \qquad N_{ch} \ge 0$$

IV. Experimental Results:

In the experimental results, static and dynamic large wireless topologies are considered in this simulation model with a predefined number of multiple channels. All the wireless nodes are randomly distributed in the topology using the initialization metrics. Each node is filled with node properties such as node id, range, node data, hop nodes, neighbor nodes etc. Experimental results are simulated in the java environment using static and dynamic parameters. Experimental results are performed in different channel rates 18,36,54 Mbps and different node transmission rates such as 60,80,120,160 bit rates.

ESI (Energy Satisfaction Index): It is a computational measure used to compute the network energy consumption in the given network flow.

BSI(Bandwidth Satisfaction Index):=1, if $F_a . \mathrm{F}^{-1}{}_r > 1$

$$= F_a . \mathrm{F}^{-1}{}_r > 1$$

Where F_a represents :Achieved Node-to-Node network latency in the dense network.

$F^{-1}{}_r$: Required Node-to-Node network latency in the dense network.

Also, $0 \le BSIValue \le 1$.

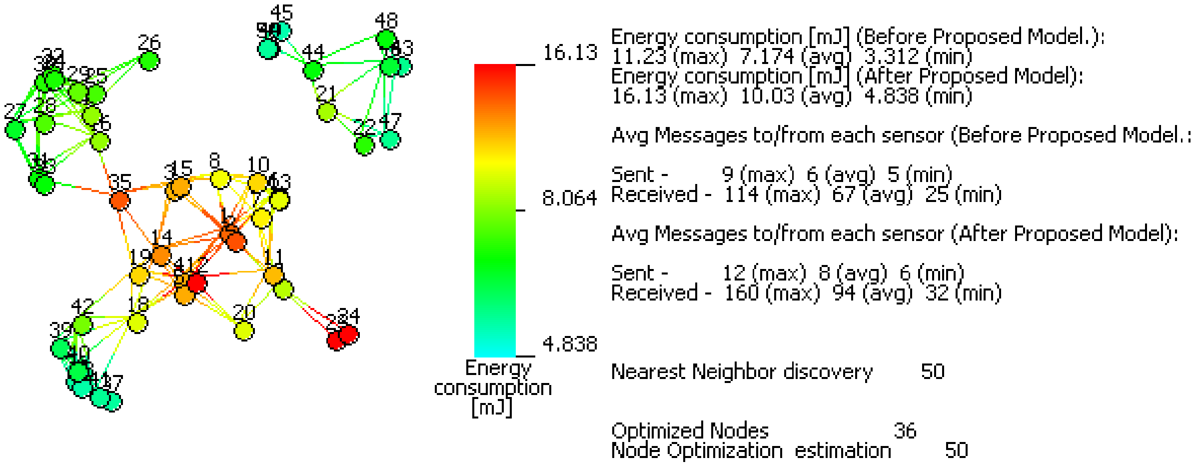


Figure 1: Energy efficiency and node access connectivity for 50 wireless nodes

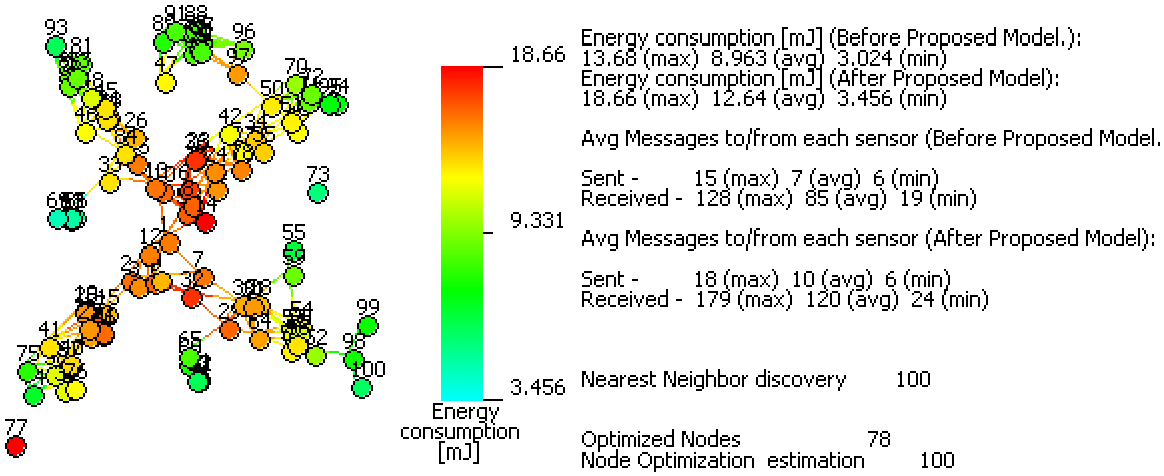


Figure 2: Energy efficiency and node access connectivity for above 50 wireless nodes

Table 1: Energy efficiency and runtime comparison of the proposed model with the existing models on 50 wireless nodes

Number of Nodes :50		
Models	**Energy Consumed(mJ)**	**Time(ms)**
S-MAC	23.5	5343
DW-MAC	21.45	4956
R-MAC	19.19	3895
Proposed Model	15.8	3193

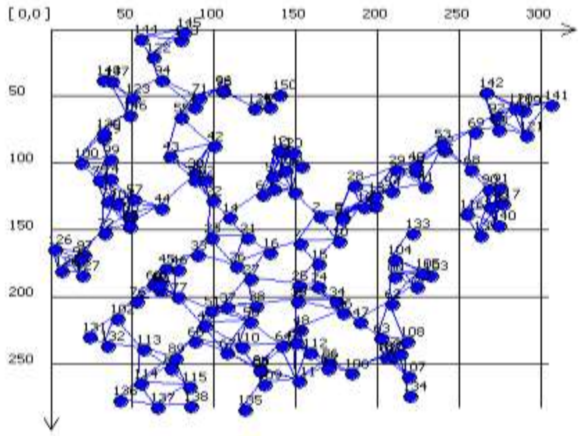


Figure 3: Initialization of the 150 size wireless nodes using random topology

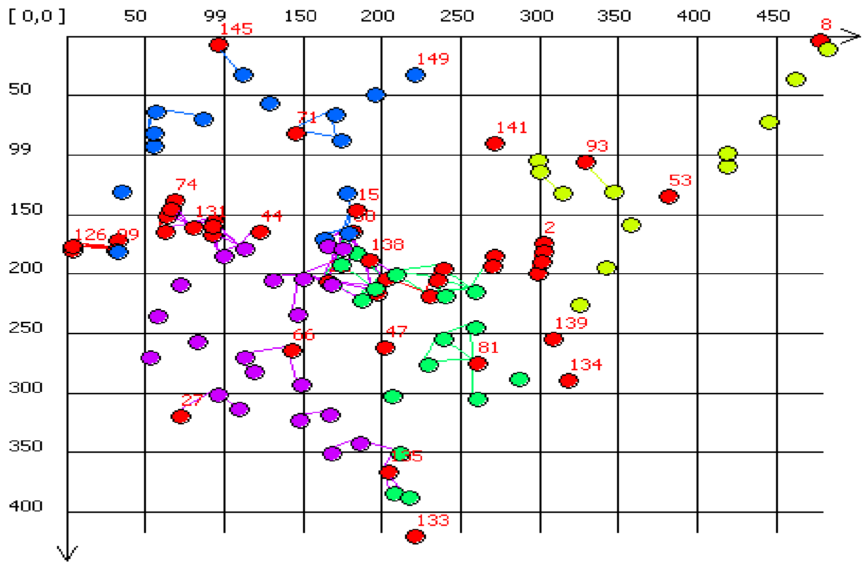


Figure 4: Optimization of the wireless nodes using the probabilistic optimization function with different energy levels.

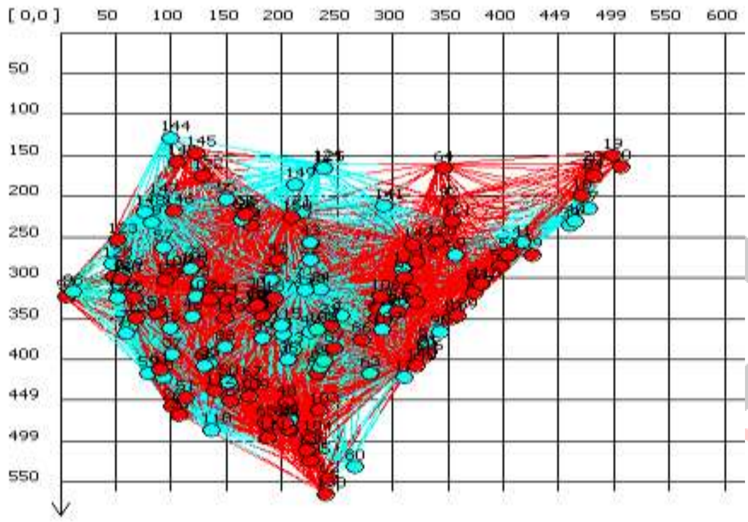


Figure 5: Optimization of node connectivity and node access paths in the dense wireless networks.

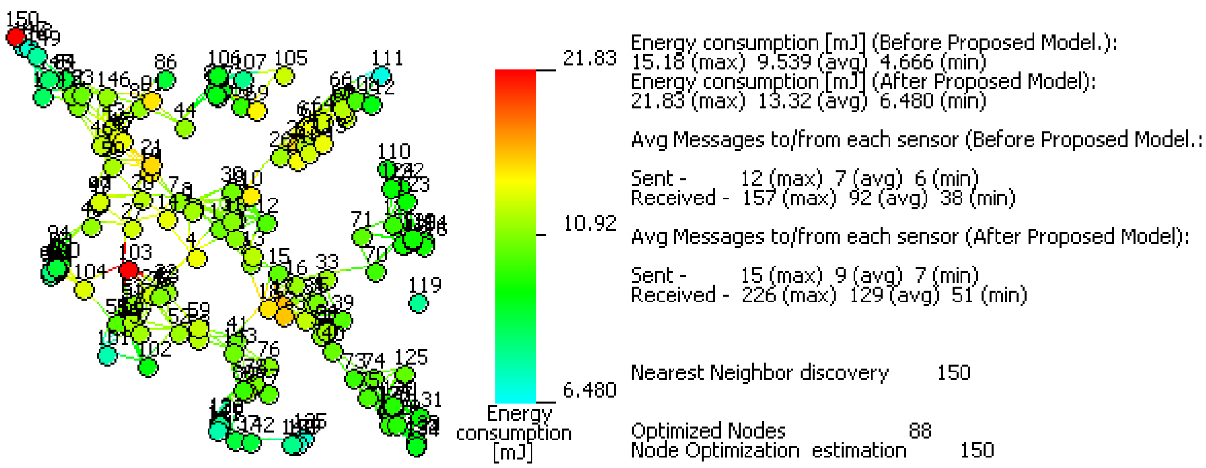


Figure 6: Final optimization of the energy and node access structure of the 150 sized wireless dense network .

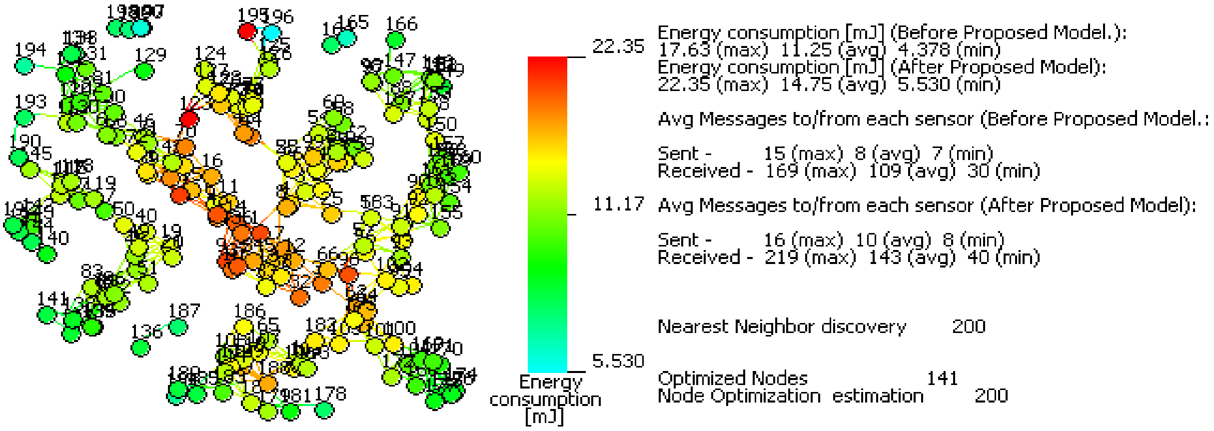


Figure 7: Final optimization of the energy and node access structure of the 200 sized wireless dense network.

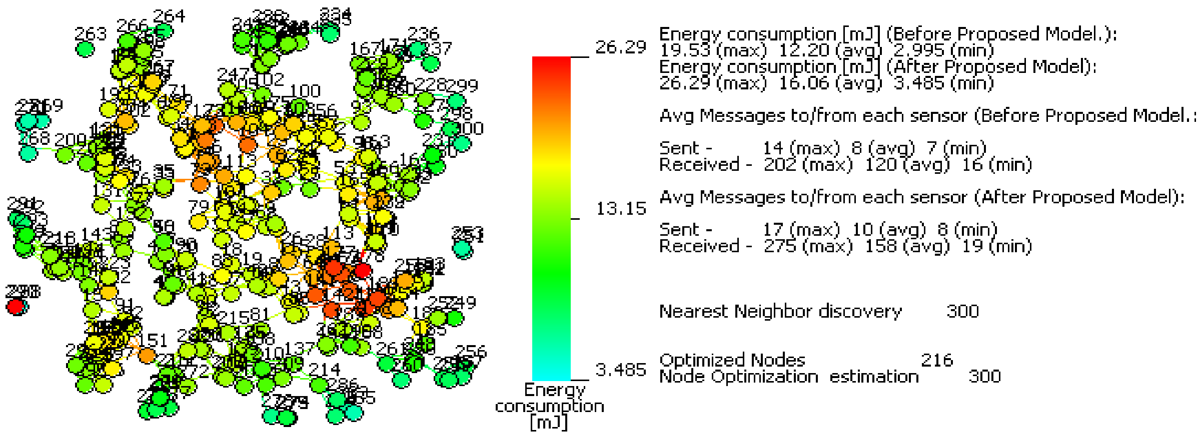


Figure 8: Final optimization of the energy and node access structure of the 300 sized wireless dense network.

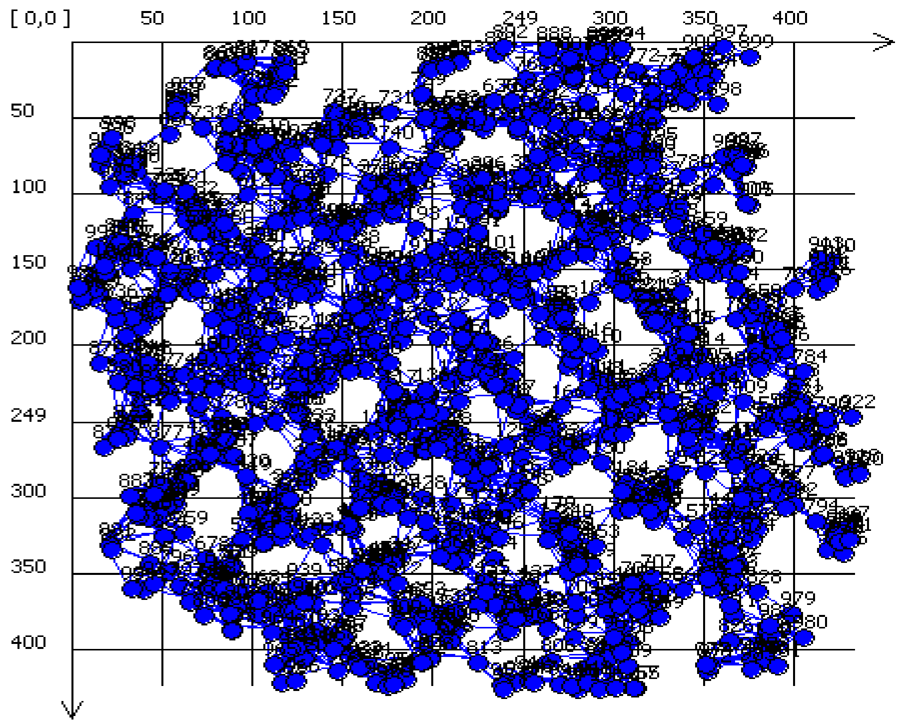


Figure 9: Initialization of the 1000 size wireless nodes using random topology

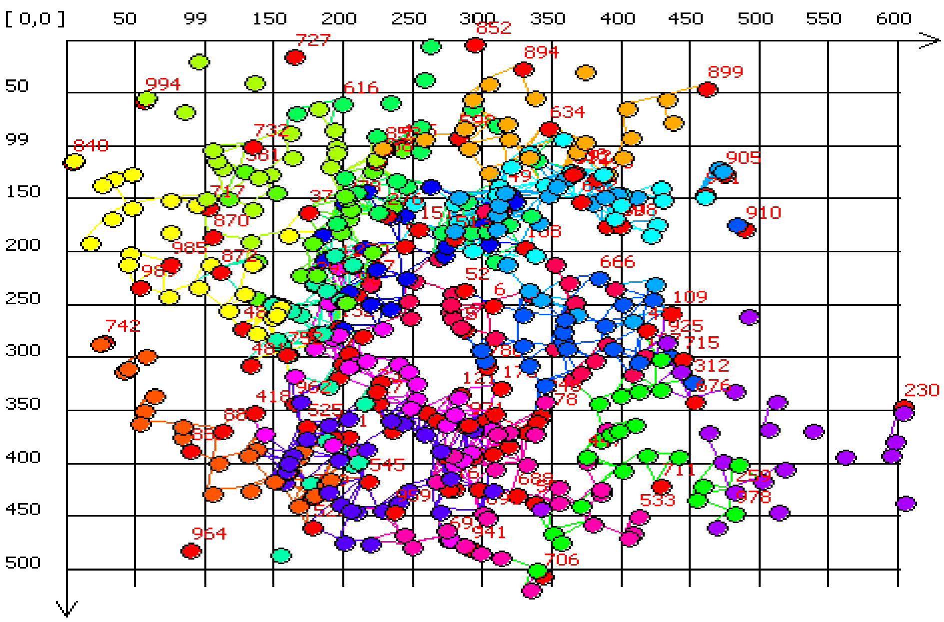


Figure 10: Optimization of the wireless nodes using the probabilistic optimization function with different energy levels.

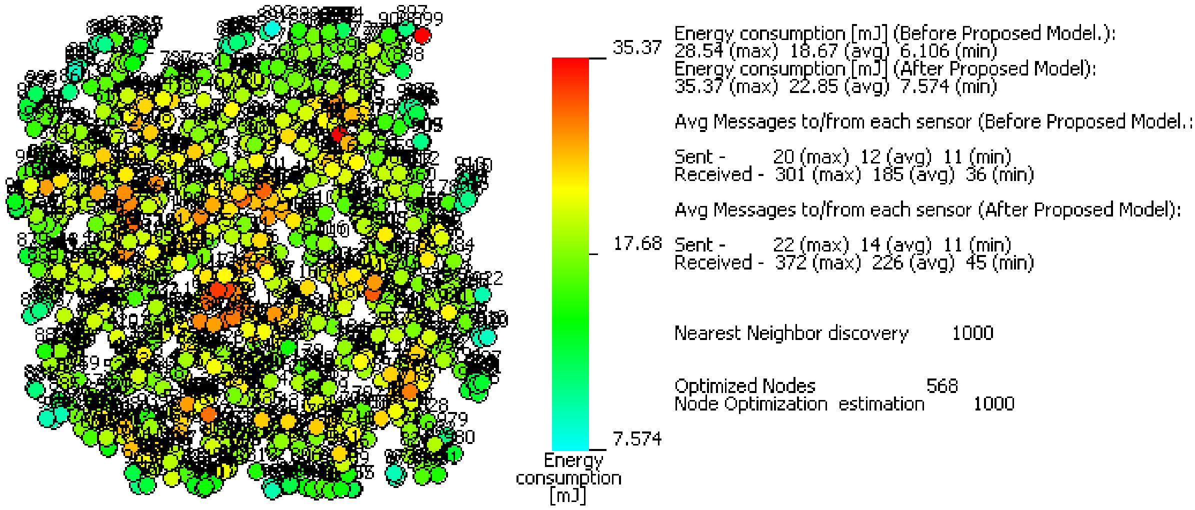
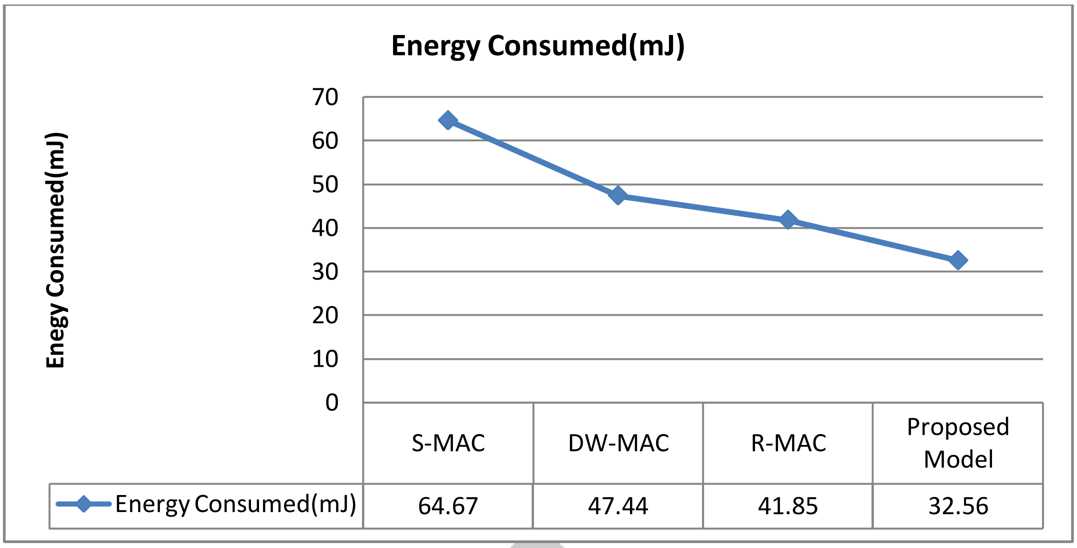


Figure 11: Final optimization of the energy and node access structure of the 1000 sized wireless dense network.

Table 2: Energy efficiency and runtime comparison of the proposed model with the existing models on 1000 wireless nodes

Number of Nodes :1000		
Models	**Energy Consumed(mJ)**	**Time(ms)**
S-MAC	64.67	9364
DW-MAC	47.44	8749
R-MAC	41.85	8034
Proposed Model	32.56	7834



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