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Reverse Order Cost Selection method to overlay Coverage in Wireless Networks

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Abstract*— Wireless Sensor Networks (WSNs), which are two or three dimensional systems, usually consist of a large number of small sensors equipped with some processing circuit, and a wireless transceiver. In this research work, it has been observed that HA-ECMSE routing reduce only the power of radio transmission and is therefore not suitable for heavy-duty applications. However, HA-ECMSE protocols can maintain network connectivity but do not guarantee coverage-hole detection. Therefore, HA-ECMSE cannot be used for networks with variable workloads. So, an enhancement to the existing system is done by proposing a novel technique Reverse Order Cost Selection (ROCS) method to overlay the coverage-hole problem in Wireless Sensor Networks. After the initial random deployment of the sensors, the position of the sensors is found out either by the GPS. The transmission range of the sensors is used to compute the coordinates of the sensors in the proposed method. Once the position of the nodes is found out, the probable location of coverage-hole is checked at a point of Region of Interest (ROI). Then, the WSN nodes are selected according to their position like nodes are closer to coverage-hole, nodes are not closer to coverage-hole and nodes includes the coverage hole. The simulation result shows that the proposed ROCS method is better than the existing HA-ECMSE method. The ROCS method shows the 0.97 % of improvement PDR, 6.55 % of improvement forwarding counts, 8.88 % of improvement packet retransmission and 27.84 % of improvement in total energy consumption when compared to HA-ECMSE method.

***Keywords*— WSN, Energy, Coverage Hole Problem, Transmission range, routing methods.**

I. INTRODUCTION

Recent advances in miniaturization, the design of low-cost, low-power circuits and wireless communications have led to the development of low-cost, low-power, and tiny communication devices called sensors. Each sensor node has wireless detection, processing and communication capabilities. A wireless sensor network (WSN) consists of a large number of sensors that are implemented in a field of interest to monitor specific phenomena. Sensors can participate in various sensing tasks, such as temperature, sound, vibration, light, humidity, etc. These sensors detect the phenomenon of the specific environment and perform local processing of the detected data before sending their results to the base station (BS). In WSN, sensors communicate with each other via multi-hop communication links and transmit data collected on behalf of third parties so that the BS can receive data in time for further processing and analysis. The WSN can be used for a wide variety of applications related to supervision (monitoring of health environments, control of earthquakes, etc.), control (detection and tracking of objects) and surveillance (monitoring of battlefields).

WSN has several intrinsic characteristics. First of all, the sensors are very small and more susceptible to hardware failure; therefore, the battery is the most critical resource. Secondly, the sensors are implemented in a high density field to extend the useful life of the network. The use of a large number of sensors facilitates communication between them and, therefore, the sensors can save energy by forwarding the data detected over short distances.

Third, the network topology can change very frequently. Therefore, the protocols designed for WSN must consider all these characteristics so that the networks remain operational for a longer period.

II. RELATED WORK

WSN is a distribution of sensors in a defined area for the purpose of monitoring and collecting a data set. Monitor physical or environmental scenarios such as temperature, humidity, sound and pressure in different places. This chapter represents coverage-hole and connectivity issue in wireless sensor networks.

Nader Mohamed et.al. (2013) [1] developed two models to use mobile sensors to help recover from these flaws and get better coverage. The first model uses mobile sensors to cover the holes, while the second model has the task of reallocating the mobile sensors previously used to acquire the greatest possible coverage. In both models, additional mobile nodes can give additional detection coverage, as well as allow connectivity between disconnected segments in the LSN. Evaluations and comparisons between both models are provided. Additionally, an analytical model is developed and validated to discover the predictable amount of mobile sensors needed to preserve high coverage in an LSN with specific configurations.

Harish Chintakunta et.al. (2014) [2] developed distributed algorithms to detect and locate the cover holes in sensor networks. They do not take information on the coordinates of the nodes, nor any distance between the nodes. They used algebraic topological methods to define a cover hole and develop a probably correct algorithm to detect a hole. Then they subdivide the network into smaller secondary networks, making sure the holes are kept and the holes in each are checked. They have shown that the repetition of this process leads to the localization of the covering.

Hamid Mahboubi et.al. (2014) [3] developed efficient sensor implementation strategies to increase coverage in wireless mobile sensor networks. The sensors find the cover holes inside their Voronoi polygons and then move in an appropriate direction to minimize them. New strategies are introduced based on the edges and based on vertices and their actions are compared with existing techniques. The proposed motion strategies are based on the distances of each sensor and the points within its Voronoi polygon from the edges or vertices of the polygon. The simulations confirm the effectiveness of the proposed implementation algorithms and their superiority with respect to the techniques reported in the literature.

Nikitha Kukunuru et.al. (2014) [4] proposed an approach called Hybrid Hole Detection and Healing (HHDH) using VorLag and the virtual force algorithm to effectively detect and treat the lid hole with minimal sensor movements. The proposed HHDH uses a VorLag approach to detection and a virtual force algorithm to heal the formed cover hole due to random implementation. A special feature of HHDH is that it implements a hole cure controller (HHC) and determines the hole cure region (HHR). The determination of HHR helps HHC to select an appropriate node for the healing process. Only the nodes that are in the appropriate positions are involved in the healing procedure. HHDH is a distributed cover hole healing algorithm that exceeds the VorLag and the existing virtual force algorithm.

Sami Mnasri et.al. (2015) [5] proposed a mathematical formulation and a genetic approach to solve this problem. Finally, present the results of the experiments. This article presents a genetic algorithm that tries to find an optimal or almost optimal solution for the problem of cover holes. Compared to random implementation and existing methods, the genetic algorithm shows a significant improvement in performance in terms of quality.

Prasan Kumar Sahoo; Wei-Cheng Liao et.al. (2015) [6] proposed efficient distributed cover hole repair algorithms that take node density in the post-deployment scenario. The proposed algorithms consider the limited mobility of the nodes and can select the mobile nodes based on their degree of coverage. To repair the network cover holes, nodes with the highest density move to maintain a uniform network density without increasing the degree of coverage of the neighbours of a mobile node. The results of the simulation show that the energy consumption due to the mobility of the nodes is lower than other similar protocols of wireless sensor networks. Furthermore, it is noted that a significant amount of overlapping can be minimized and the percentage of hole coverage can be maximized.

Kamran Latif et.al. (2016) [7] addressed the problem of creating power holes in depth-based routing techniques and designed a technique to overcome shortcomings in existing techniques. In addition to addressing the problem of the energy hole, the proposal for a cover hole repair technique is also part of this document. In dense deployment areas, the detection intervals of the node overlap redundantly. Our proposed technique exploits a redundant overlap and repairs a cover hole during network operation. Simulation results have shown that two techniques consistently conserve node energy, which ultimately maximizes useful life and network performance at the expense of greater delay.

Ahmad Raza Hameed et.al. (2017) [8] proposed an algorithm to alleviate the hole problem using the geographic routing strategy for wireless sensor networks (WSN). To obtain the desired results, an optimal number of promoter nodes is calculated together with the selection of the path that has a minimum energy consumption. Moreover, in every jump the residual energy of a sensor is calculated and the knowledge rises to a near neighbour of the promoter node, which guarantees the avoidance of the problem of the energy hole. The simulations are performed to validate our request to overcome the existing schemes compared in terms of the package delivery ratio (PDR) and power dissipation of the network nodes.

III. PROBLEM IDENTIFICATION

1. It has been observed that HA-ECMSE routing reduce only the power of radio transmission.
2. HA-ECMSE only reduces inactive power consumption and is therefore not suitable for heavy-duty applications.
3. However, HA-ECMSE protocols can maintain network connectivity but do not guarantee coverage-hole detection.

Therefore, HA-ECMSE cannot be used for networks with variable workloads. So, an enhancement to the existing system is done by proposing a novel technique Reverse Order Cost Selection (ROCS) method to overlay the coverage-hole problem in Wireless Sensor Networks. The proposed ROCS method is discussed in next section.

IV. PROPOSED RESERACH METHODOLOGY

The First, it was observed that coverage detection and network connectivity are the two important issues that significantly affect the QoS of a WSN. Almost all documents concern the goal of dream programming, such as minimizing energy consumption or maximizing the useful life of the WSN network.

Most of the protocols in the literature do not allow different degrees of coverage required by the applications. Some programming algorithms pay little attention to network connectivity. In some cases, message overload is high.

Therefore, a protocol of greater energy efficiency should be proposed in which coverage, connectivity and arrangement are considered together. Therefore, the existing protocols are not adaptable to the various node distributions or to the various detection areas.

There are also additional overhead costs when selecting the cluster head (CH) and the cluster building process. Therefore, to overcome these limitations, an efficient dynamic protocol should be proposed. Furthermore, they only determine the location of the forwarding nodes and do not solve the routing problem.

The flowchart of proposed system is shown in above figure 1. When the sensor nodes are deployed into a particular area, some area not covered in the sensor rage; which may create and leads the coverage-hole problem. Sender node sends the data packets towards sink or recipient node, it establish the route and update the position with energy level of nodes (sender, receiver and neighbor nodes).

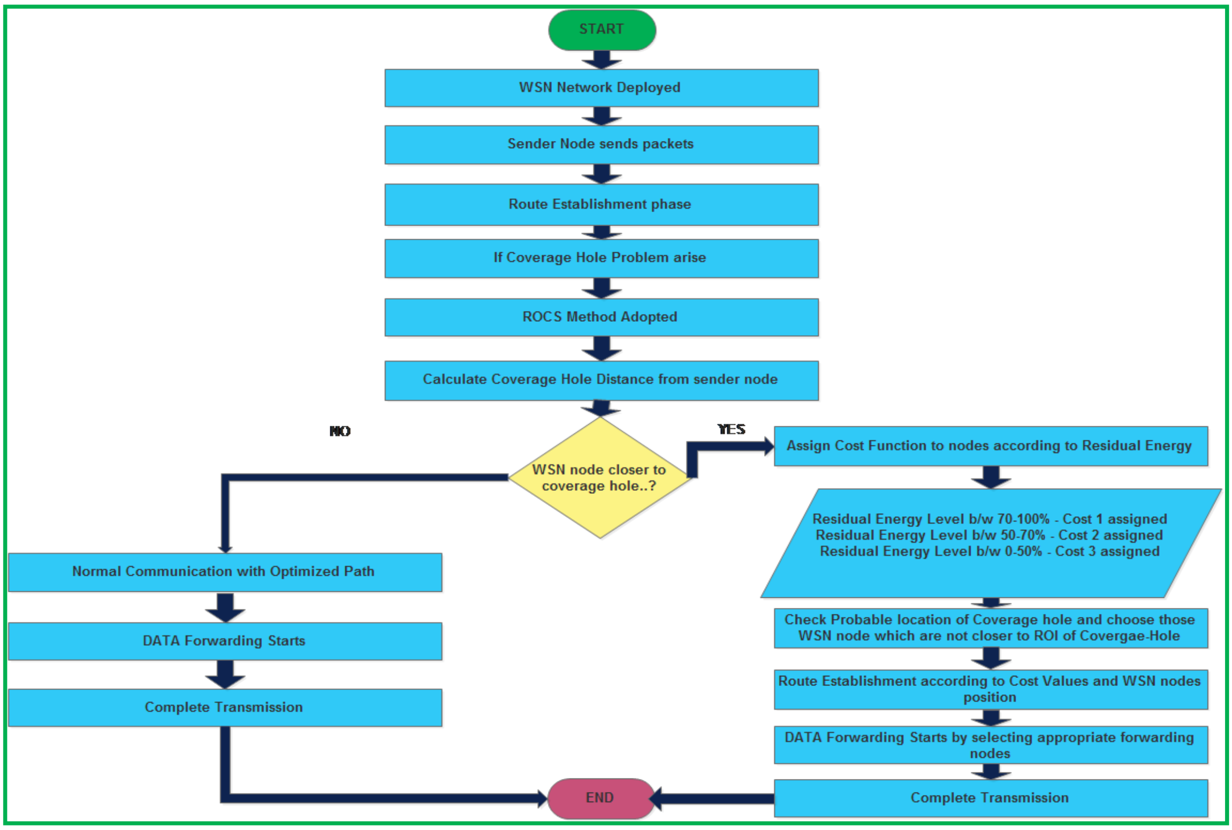

Figure 1: Proposed ROCS method flowchart

Some assumptions are made about deployment of Wireless Sensor Networks:

1. The nodes after deployment are fixed.

2. There are multiple sender nodes and multiple sinks (destination nodes).

3. The sinks are fixed whose position is determined by distance calculating algorithm.

4. The area to be sensed is large enough and the nodes are scarcely deployed.

5. All the nodes are homogeneous.

After the initial random deployment of the sensors, the position of the sensors is found out either by the GPS. The transmission range of the sensors is used to compute the coordinates of the sensors in the proposed method. Once the position of the nodes is found out, the probable location of coverage-hole is checked at a point of Region of Interest (ROI). Then, the WSN nodes are selected according to their position like nodes are closer to coverage-hole, nodes are not closer to coverage-hole and nodes includes the coverage hole.

Once the routes are setup, the nodes start sending the data to the sink (destination) and the sink aggregates and interpret the data, the forwarding nodes selected in a way which is not closer to coverage-hole depending upon the application for which the WSN is employed. Those nodes which are closer to coverage-hole or may include the coverage-hole is tried to be lesser in an optimized energy path for sender and destination nodes.

The number of forwarding nodes in the higher-level network provides coverage and connectivity. For higher residual energy level of WSN node, the cost 1 is assigned i.e. low cost; while for lower residual energy level of WSN node, the cost 3 is assigned i.e. high cost. The forwarding nodes are selected according to higher residual energy level; hence the name is decided for proposed work as "Reverse Order Cost Selection (ROCS)".

Therefore, the joint optimization is proposed for positioning with their cost values and routing conscious energy of forwarding nodes in a wireless sensor networks. The proposed system would be implemented using Network Simulator 2 and compared with the existing methods in terms of Packet Delivery Ratio (PDR), Energy Consumed, No. of forwarding counts and Packet retransmission.

V. PERFORMANCE PARAMETERS

The goal of this research work to study the relative performance of each selected routing protocol named as HA-ECMSE and ROCS protocol with respect to varying scenarios and traffic loads. Pre-generated scenario files are used to subject each protocol to the same set of scenarios and traffic loads in an identical fashion to perform a fair comparison. This section presents in detail about the performance metrics. The performance metrics are used to quantitatively evaluate the WSN based routing protocols which would be more efficient to coverage hole problem. In this research after simulation, evaluation is done on the basis of following parameter.

A. Packet Delivery Ratio (PDR)

It is the output of total number of delivered packets divided by total number of sent packets, mathematically it is calculated as:

PDR= (No .of Dropped Data Packets)/ (No. of Sent Data Packets)

The higher the PDR metric lead to the higher rate of delivered routing packets and consequently the higher the efficiency of the protocol.

B. Forwarding Counts

It is calculated as total number of packets forwarded by neighbor nodes involved communication path between sender and destination. This metric should be as smaller as possible. It is calculated by following equation:

Forwarding Counts= (No. of Forwarded Data Packets)/ (Total No. of Nodes)

C. **Total Energy Consumption**

The total energy consumed, includes the energy consumed by the control packets, to transport one kilobyte of data to its destination node.

Total Energy consumption=∑ (Initial Energy-Remaining Energy) ∀ all nodes

The total energy consumption of nodes should be minimal as much as possible since it decides the longevity of the network.

D. **Packet Retransmission**

Retransmission is the forwarding of packets that have been corrupted or lost during communication between the sender and the recipient. Retransmission is one of the fundamental mechanisms used by protocols that operate through a network to provide reliable communications.

Packet Retransmission=∑ ((f +D + L) ∀ all nodes)/ (Total no. of nodes)

Where f= total number of forwarded packets

D= total number of dropped packets

L= total number of lost packets (error)

The retransmission of packets should be less in a routing protocol since it affects the efficiency of a protocol.

VI. SIMULATION SETUP & RESULTS

The goal of this research work to study the relative performance of selected energy efficient techniques named as HA-ECMSE and ROCS methods with respect to varying scenarios and traffic loads. Pre-generated scenario files are used to subject each method to the same set of scenarios and traffic loads in an identical fashion to perform a fair comparison.

Table 1: Simulation parameters setup

Parameters	Value
Simulator Version	Network Simulator 2.35
Mobility Model	Random Way-point
Performance Parameters	Packet Retransmission, Total Energy Consumption, Forwarding Counts, Packet Delivery Ratio
Methods Analysed	ROCS & HA-ECMSE
Simulation Time	150 seconds
Traffic Type	CBR
Environment Area	1000 x 1000 meters square
Initial Energy	10.0 Joules
Transmission Energy	0.33 Joules
Idle Energy	0.10 Joules
Data packet Size	512 bytes
Transmission Range	250 meters

The Figure 2 shows the forwarding count graph for both HA-ECMSE and ROCS methods. The number of forwarding counts is higher in case of scenario 1, since the location of coverage hole is nearer to the WSN nodes and hence more number of packets is forwarded. So the WSN node requires transmitting the packets again. In the graph it could be seen that ROCS method is well adapted in WSN converge hole environment than HA-ECMSE method. .

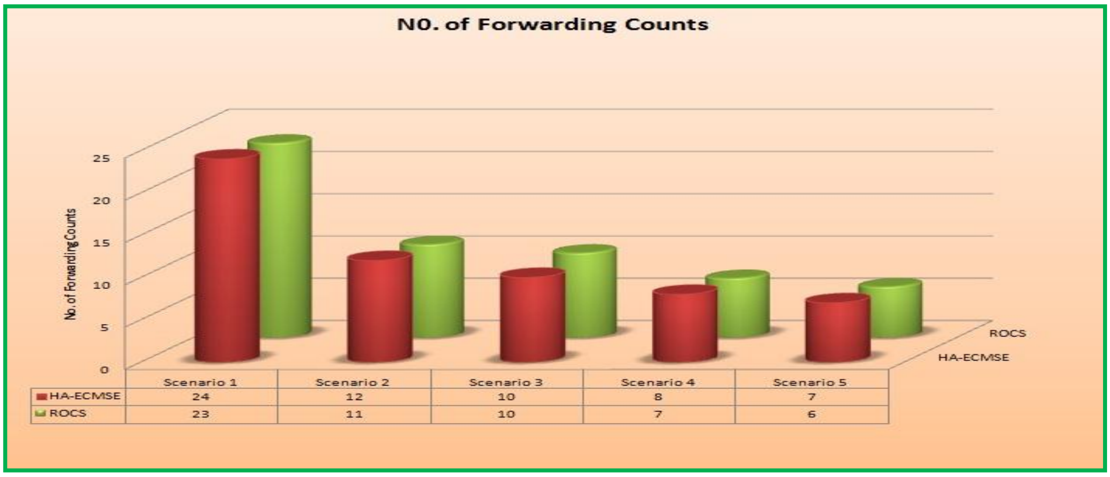

Figure 2: Number of Forwarding Counts

The Figure 3 shows the number of packet retransmission graph for both HA-ECMSE and ROCS methods. The number of packet retransmission is increasing continuously, since the location of coverage hole is farther to the WSN nodes and hence more number of packets is dropped or lost via forwarder node or intermediate node. So the WSN node requires transmitting the packets again by sender side. In the graph it could be seen that ROCS method is well adapted in WSN converge hole environment than HA-ECMSE method.

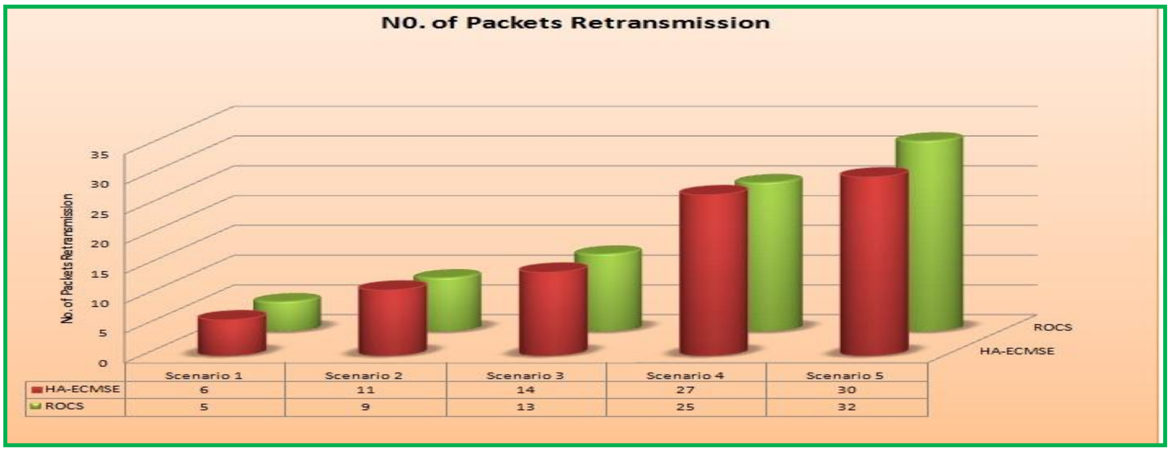

Figure 3: Number of Packet Retransmission

Figure 4 shows the number of packet delivery ratio graph for both HA-ECMSE and ROCS methods. The number of packet retransmission is decreasing continuously, since the number of nodes is increased with each scenario and hence less number of packets is received by sender side. In the graph it could be seen that ROCS method is well adapted in WSN converge hole environment than HA-ECMSE method.

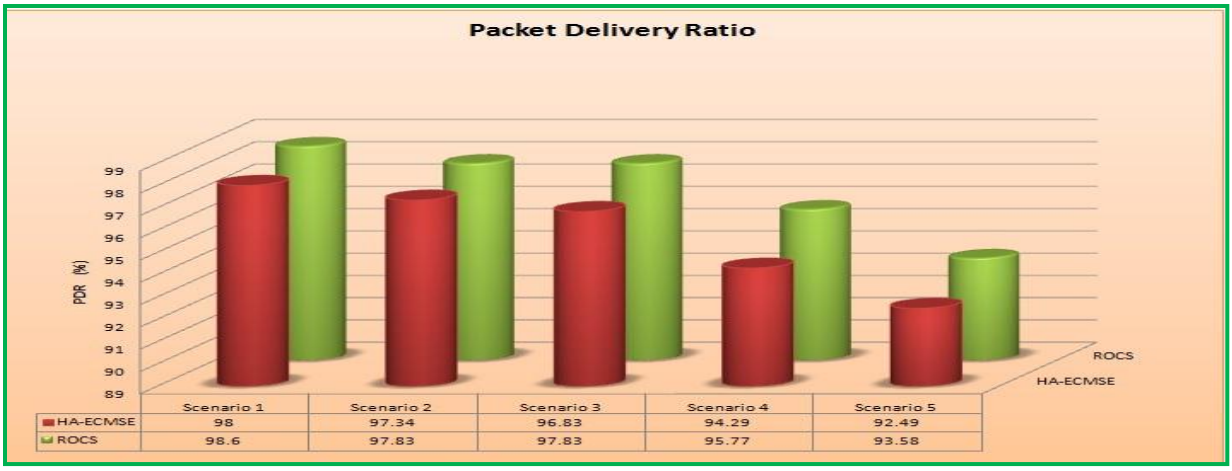

Figure 4: Packet Delivery Ratio

Figure 5 shows the Total Energy Consumption graph for both HA-ECMSE and ROCS methods. The Total Energy Consumption is increasing continuously, since the number of nodes is increased with each scenario and hence the energy consumption of nodes would also be increased with each node included in WSN. In the graph it could be seen that ROCS method is well adapted in WSN converge hole environment than HA-ECMSE method.

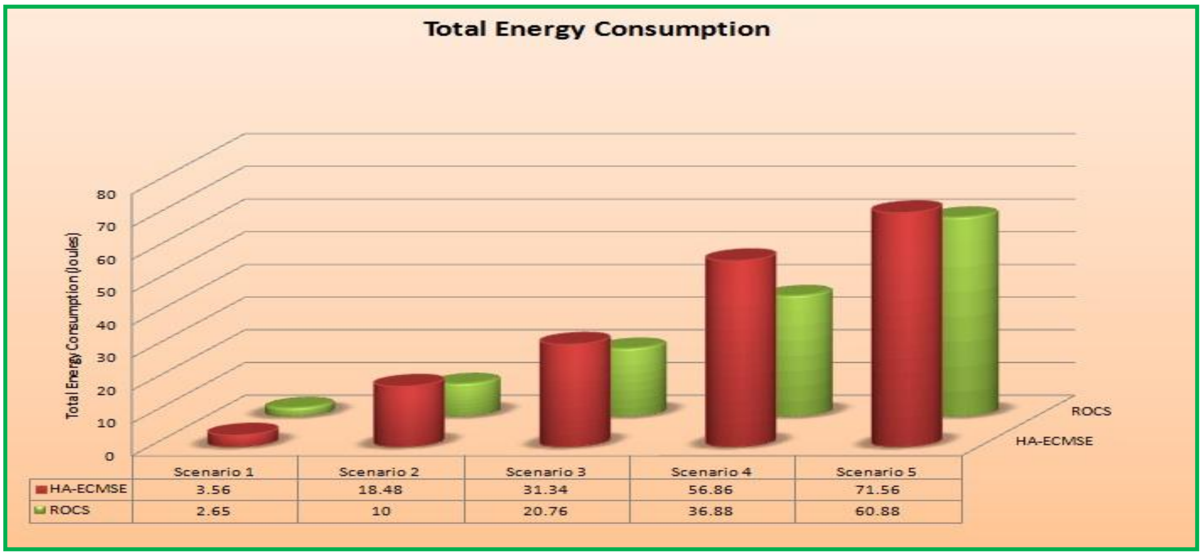

Figure 5: Total Energy Consumption

VII. CONCLUSION & FUTURE WORK

In This thesis illustrates the working of coverage hole alleviation using geographic routing algorithm against location errors for WSNs (HA-ECMSE). There are some advantages and disadvantages of the existing method and problem are identified. Although the HA-ECMSE method works perfectly in WSN coverage environment and HA-ECMSE cannot be used for networks with variable workloads. So, an enhancement to the existing system is done by proposing a novel technique Reverse Order Cost Selection (ROCS) method to overlay the coverage-hole problem in Wireless Sensor Networks.

First, it was observed that coverage detection and network connectivity are the two important issues that significantly affect the QoS of a WSN. Almost all documents concern the goal of dream programming, such as minimizing energy consumption or maximizing the useful life of the WSN network.

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Therefore, the joint optimization is proposed for positioning with their cost values and routing conscious energy of forwarding nodes in a wireless sensor networks. The proposed system would be implemented using Network Simulator 2 and compared with the existing methods in terms of Packet Delivery Ratio (PDR), Energy Consumed, No. of forwarding counts and Packet retransmission.

The table 2 shows the percentage of improvement of ROCS method when compared to HA-ECMSE method with respect to performance evaluation parameters.

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Table 2: Percentage of Improvement

Parameter	**HA-ECMSE Method**	**ROCS Method**	**Percentage of Improvement**
Packet Delivery Ratio (%)	95.79	96.72	0.97 **%**
Forwarding Counts (Fraction value)	12.2	11.4	6.55 **%**
No. of Retransmission (Constant)	18	16.4	8.88 **%**
Total Energy Consumption	36.36	26.23	27.84 %

The following future research studies can be performed.

- This work can be extended to irregular sensitivities and sensor communication intervals.
- In most implementations of the sensor network, sensors in the central positions contribute more to forwarding activities while the nodes at the ends do not participate in forwarding. This problem can also be considered for further improvements and analysis.
- ROCS can be extended to treat open holes formed at the limit of the network.

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