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# EFFICIENT HYBRID NOVEL CLUSTERING BASED ENERGY HARVESTING WSN BASED IOT APPLICATIONS

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**ABSTRACT**
*Wireless Sensor Network (WSN) is a collection of sensor nodes communicate with each other and sharing the information between the networks. Sensor nodes are low power and low cost devices are used to construct the network. Sensor based networks are used in various integrated applications. One of the most benefited sensor based application is Internet of Things (IoT) applications. In IoT applications, the physical components are data sources and collected information's are transmitted through the network in the mode of intermediate node access. All the physical components or sensors are battery powered in nature, so the energy was play a vital role in WSN based IoT applications. Energy of nodes will decide the lifetime of network and accurate data transmission between the nodes. The future of WSN is purely dependent on the Energy saving mechanism and now it is create a new dimension of research constraint. Now, the researchers focusing on the Energy Harvesting techniques for improve the lifetime of the network. We propose a new EH-WSN based hybrid novel clustering based routing approach called Energy Efficient Clustering and Route Optimization Scheme in Energy Harvesting Wireless Sensor Networks (EECROS-EHWSN). The proposed scheme combined with two aspects, initially, the node energy information's are collected and based on the energy level it is clustered. Secondly, the route formation between the nodes and data transmission is made through the genetic based approach. Our proposed approach will provide the efficient usage of energy, packet delivery ratio and throughput.*

*Keywords: WSN, Sensor nodes, IoT Applications, Energy Consumption, Energy Harvesting, Clustering, Genetic Approach.*

## 1. INTRODUCTION

WSN includes sensor nodes which have the functionality of self-configuration and its deployment in target area is so clean. WSNs have a few boundaries in terms of battery power, data transmission, storage, and processing.

Energy efficiency is one of the maximum crucial factors in designing a WSN. As WSN is deployed in many adversarial and extreme environments, it isn't always viable to deliver energy supply or recharging facility. A complete network has to carry out its challenge on the embedded batteries. If a few nodes died because of low battery power, it can result in the breakdown of complete network termed as network partitioning [1], so one of the most important functions is to extend the WSN lifetime [2]. Built-in energy technology together with batteries is continuously improving [3], and there are numerous energy saving strategies for WSNs [4]. However, most of WSNs are deployed in harsh environments wherein there is a want of environmental energy harvesting. Energy harvesting is a mechanism in which sensor nodes have the capacity to extract energy from surroundings, shop it, and then use it each time wished. In WSN more energy is used in statistics transmission from supply to multihop away destination. This is the reason; energy-green routing is constantly suited in such sort of networks [5]. Energy efficiency can be performed via making use of clustering mechanism in WSN. Clustering is a way wherein many sensor nodes are grouped together to perform a undertaking. Cluster head is chargeable for monitoring all of the nodes in its own cluster. In cluster-primarily based WSN, routing mechanism is extra simple and easy in comparison to noncluster WSN. Cluster head allows the routing protocol to reliably send facts from source to destination.

Energy Harvest routing is fairly applicable for multihop wireless networks including WSN. Multihop wireless networks are sharing the information between the nodes compared to single hop wireless networks. The reason is that maximum of multihop wireless networks are disbursed having no centralized frame. Designing the proper growth the lifetime of the network primarily based routing for WSN is a difficult challenge. In WSN, an appropriate routing protocol ought to be efficient in phrases of energy consumption.

In this paper, we present an energy efficient routing protocol that's based on clustering based totally statistics change and power harvesting approach. Our thought is capable to constantly monitor the power consumption and select comfy and energy-efficient path from supply to destination. In the relaxation of the paper is organized as follows. Chapter 2 discusses about the associated work of the proposed system. Protocol selection issues and parameters are addressed in Chapter 3. Chapter 4 describes the performance evaluation parameters and simulation effects. Chapter 5 concludes the paper and affords our destiny paintings. It is essential to recall energy boundaries at the same time as designing any mechanism for WSN. Majority of modern-day energy-green routing protocols determine green use of power. Such mechanisms may additionally boom the lifestyles time of WSN, however do no longer provide harvesting of node power to provide long lasting solution.

## 2. LITERATURE SURVEY

Most IoT nodes are commonly battery powered and that makes energy efficiency critical for proper functioning and management of those nodes. Energy efficiency and sufficiency in IoT sensor nodes had been active research regions. IoT nodes have restrained energy and communique among the special nodes is energy consuming. Many low-powered communique technologies are evolved and considered these days as allowing technology for IoT. These encompass, technologies enabling “matters” obtaining contextual information, technologies allowing “things” processing contextual facts, and technology improving safety and privateness.

IoT sensor nodes may as well benefit from energy harvesting technologies, like, vibration or electromagnetic radiation, ambient light, thermal energy, that have the capability to provide much enhanced power to the nodes. A sensor node’s basic components include, a sensor microcontroller, a power harvesting transducer, an energy conversion system, and the wireless radio used for communications. Thus, for such nodes to optimally benefit from energy harvesting, there is a need to have an efficient power conversion system, energy storage system, and power management system. On the flip side, specifically speaking of ambient energy sources, their specialized requirements for deployment may cause the overall applications costs to go up.

**Wang, Z., et al. (2018)** addressed the fifth-generation (5G) networks to realize innovative IoT based applications, such as smart city and intelligent manufacturing. MTC devices with sensing and communication capabilities can monitor the surrounding environment and transmit the collected information back to Base Station (BS) for further data analysis [6]. The dense deployment of sensing devices calls for a clustering structure to pre-process the redundant data to avoid traffic overload. Moreover, due to limited battery capacity, the energy cost remains a critical concern in such IoT systems. The proposed work introduces an energy-efficient clustering routing algorithm. Considering the non-uniform traffic distribution, the proposed work introduces an uneven cluster formation scheme for load balancing and energy efficiency. Moreover, propose a distributed cluster head (CH) rotation mechanism to balance energy consumption within each cluster. As for long distance transmission to BS, design a dynamic multi-hop routing algorithm among CH nodes based on a proposed distance-and-energy-aware cost function to avoid the energy hole problem. Simulation results show that the performance of our proposed algorithm is competitive in terms of network lifetime, throughput and energy efficiency.

**Hassan Oudani., et al. (2017)** in WSNs, the energy consumed by each node of the network influences the lifetime of the networks, more than the consumption of energy increases more than the lifetime of the networks decreases [7]. This is because the increase of the lifetime of the networks requires a strategy (protocol) which reduces the power consumption of the transmission or reception of data by the sensor nodes. In recent years extensive research has been done to maximise a lifetime of network sensor. In order to deal with this, the hierarchical protocols (cluster based-approach, chain based-approach) have been developed to reduce the network traffic toward the sink and therefore prolong the network lifetime. Its focus is driven over the survey of the energy-efficient using hierarchical cluster-based approach namely LEACH (Low Energy Adaptive Clustering Hierarchy Protocol), to propose a new method to maximise more the lifetime of network sensor. The LEACH method conserves energy consumption when transmitting data to the BS. The study evaluates the performance of the LEACH protocol with the proposed method simulated; the results of the method are proved by the simulation results using MATLAB Simulink.

**Singh. A., et al. (2016)** discuss the CH and CH selection is and a method of energy-efficient routing is presented based on both particle swarm optimisation technique and V-LEACH protocol [8]. Performance comparison with existing leach protocol shows proposed protocol provides better performance to minimise energy dissipation in the transmission and increases the lifetime of the WSNs, also other comparative performance metrics such as End-to-End delay, data transmitted and total energy consumed shows proposed protocol provides better performance in comparison to existing leach protocol.

**Asha. G. R., (2018)** proposed that WSNs is instrumental in transferring the data gathered by Sensors mounted on the SNs to the BS [9]. The lifetime of WSN solely depends on the energy/battery life of SNs and higher the battery life longer the lifetime of the network. The sustained operation of WSN is achieved through the efficient consumption of SNs energy. In recent times, several energy conservation mechanisms have been proposed, and among them, LEACH-WSN was the most comprehensive methodology. Further, the work about the sustained energy conservation mechanisms which are enriched with bio-inspired technique or computational neural systems such as PSO-PSO-WSN, PSO-GSO-WSN, GSO-KGMO-WSN, FCM-PSO-GSO-WSN EBC-S or RSOM-WSN is reported. In order to conserve energy in WSN; SNs are clustered using a set of criteria and gather the data at each CH to avoid the redundant transfer of data to the BS. Furthermore, gathered data is routed to the BS efficiently using intelligent routing process. This approach, PSO-PSO-WSN, LEACH-WSN and EBC-S are compared with PSO-GSO-WSN, GSO-KGMO-WSN, FCM-PSO-GSO-WSN and RSOM-WSN. These methods are subjected to the Performance Evaluation (PE) in terms of alive nodes, dead nodes, energy consumption, throughput, and total data/packet delivered.

**Nurlaily, V., et al. (2018)** proposed energy is a crucial part in the WSNs. The system is cannot run according to its function without the availability of adequate power units [10]. One of the characteristics of the WSN is the Limitation of energy. Much research has been done to develop strategies to overcome this problem. One of them is the clustering technique. The popular clustering technique is LEACH. In LEACH, clustering techniques are used to determine CH, which would then be assigned to forward packets to BS. The research proposes other clustering techniques, which utilise the Social Network Analysis approach theory of BC, which would then be implemented in the Setup phase. While in the Steady-State phase, one of the heuristics searching algorithms, Modified Bi-Directional A* (MBDA*) is implemented. The experiment was performed to deploy 100 nodes statically in the 100x100 area, with one Base Station at coordinates (50, 50).

The performance of the designed routing protocol strategy would be tested based on network lifetime, throughput, and residual energy. The results show that BC-MBDA is better than LEACH. LEACH determines the CH that is dynamic, which is always changing in the data transmission process.

**Yuku, Y., et al. (2015)** aiming at the problems of existing clustering routing algorithm of self-energized WSNs on the fixed threshold for resurrection, incapacitates; reappoint cluster head in the next round and lack of election limit [11]. It proposes a novel clustering routing algorithm for self-energized WSNs clustering routing algorithm based on solar energy harvesting algorithm. The algorithm puts forward a threshold sensitive resurrection mechanism, reviving the node when harvesting energy reaches the set soft or hard energy threshold. Meanwhile, combined with current energy harvesting level, cluster head node can decide whether to reappoint the CH in the next round. What is more, CRBS optimizes the CH election threshold to limit the incompetent node in the election. Combined with the solar energy harvesting simulation, the results show that CRBS algorithm can better keep the default cluster head proportion, and outperforms Balanced Energy Clustering with Self-Energization (EBCS) algorithm in terms of surviving nodes number and the success ratio of data transmission.

The aim of this paper is to design scalable energy efficient routing protocol for M2M sensor networks with multiple mobile sink nodes. Two reasons stand behind using this approach, firstly, the ability to balance traffic load and fair energy consumption in IoT networks, secondly, the ability to solve network scalability problem and create dynamic topology to adapt variable extensions of the system in IoT architecture. The sink nodes dynamically collecting the data from cluster heads, multiple mobile sink nodes with predefined path were used to eliminate the problem of network coverage and multihop packets sending.

## 3. ENERGY EFFICIENT CLUSTERING AND ROUTE OPTIMIZATION SCHEME (EE-CROS)

Data transmission from source to destination node requires some sort of routing mechanism. Typical WSN nodes sense information and forward to sink node over multi-hop intermediate nodes using routing protocol [12]. The objective behind this work is to transmit packets along such path, which is reliable and energy efficient.

### 3.1. System Model

At present design, the WSNs based applications is a challenging task. Theoretical evaluations cannot be adequate for several cases to prevent and predict the crash of sensor networks. The design complexity of WSNs rises with growing applications and their requirements [13]. The network lifetime and minimum error margin of data transmission are mainly depending on the energy consumption of the nodes.

Consequently, different methods are proposed to reduce the energy consumption of the wireless sensor network. Designing WSNs has several problems from this point of view.

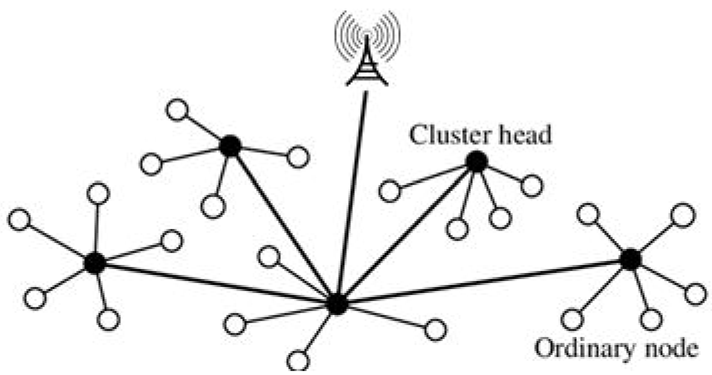


**Fig. 3.1:-** System Model

EH is a promising solution to overcome the problem of significant energy consumption and network stability. Therefore, this study proposes a clustering-oriented algorithm called (EE-CROS) to prolong the network lifetime and stability of the network. The primary advantage of clustering is the expansion of sensor networks in terms of scalability of performance. Also, the clustering approach offers several secondary benefits. It ensures reliability and avoids one-point failure through its localized solutions.

### 3.2. Network Model

The elements of this model consist of the collection of sensor nodes. The sensor nodes are supposed to be placed in an unstructured manner according to the energy perspective [14]. The sensor node performs three mandatory activities, which means sensing the data, processing the data and communicates the data. In all three functions, data communication in most cases, it is a high energy-consuming activity. Because of this, the network model adequately addresses the issue of energy consumption.

The following conclusions are made about the testbed

- The sensor node formation is done randomly
- Sensor nodes and the base station are fixed (static)
- The distance between the sensors is defined based on the signal strength and
- Data aggregation is done through the (CH).

Each senor nodes are represented as *s,* and wireless sensor network consists of n number of sensors ($s_1$, $s_2$, $s_3$, ….,$s_n$).

All the sensor nodes are transmitting their data (i) to the CH and the sensor nodes, energy consumption is represented as ($Es_1$, $Es_2$, $Es_3$, ….,$Es_n$). The CH act as an intermediate between the sensor nodes and the base station.

It performs data aggregation, integration and communicates to base station, so it needs more energy to stable the network and active (Figure 3.2). A CH handles two types of messages, one is internal messages, and other is external messages. Internal messages own messages of the CH, and the external messages are defined as the neighbour nodes data collected by the CH. A vast data handling situation occurs in this type approach, and it may fail the quality of data transmission between the cluster head and base station [15].

Data transmission is an essential factor for energy consumption in WSNs.

Hence, this study focuses on reducing the number of bits transmitting from cluster head to base station through the data compression method. Due to the extended network approach, there is a vast number of communications from the sensor node to sink or base station. It would create the overburden to the base station and fast exhaustion of the battery. In this proposed hierarchical network model differs from the existing methods, which focus on the energy harvesting type of WSNs. A data collection is made through a particular node, which reduces the number of messages sent to the base station, and this improves the energy efficiency of the network.

### 3.3. Adaptive Routing Scheme

#### 3.3.1. Energy Routing Scheme

Energy proficient and energy-mindful routing algorithms have been broadly considered. A typical normal for the greater part of these is the presumption of a battery which is step by step depleted. Consequently, the test is to discover measurable or dynamic routing methodologies which can guarantee the longest lifetime of the battery in any hub of the network. By applying low-control hardware and software systems for the structure of the hubs, the research can bring down the rate at which the battery is exhausted, and by lessening the obligation cycle, i.e., the time interims at which the hub is dynamic, this can extend the lifetime of the battery [16]. As hubs near the base station will be associated with more routing than those distant, a clear routing methodology will rapidly deplete the battery of these hubs, viably cutting of the remainder of the network from the base station. Henceforth, energy mindful routing algorithms need to consider the energy dimension of the hubs, i.e., discovering energy improved courses, where hubs with too little energy are maintained a strategic distance from.

This research presents a versatile routing algorithm which can discover and keep up energy enhanced courses from any source hub to a base station (called the sink or goal hub in the accompanying). By energy improved courses this mean courses that maintain a strategic distance from hubs with too little energy, viably enable these hubs to recover their energy level through energy collecting. The proposed algorithm is versatile and disseminated, i.e., every hub runs independently, taking routing choices dependent on accessible energy on its neighboring hubs. As every hub settles on nearby routing choices, a course may change while the information is being directed. To guarantee a net energy gain, it is critical to likewise represent the energy used by the routing algorithm itself.

In our setup this reproduces the vulnerabilities of energy gathering through worldwide parameters, for example, time of day, and nearby parameters, for example, measure of shadow for a given hub position. This imitating of the earth is seen by the proposed routing algorithm and used to direct network traffic to such an extent that hubs in territories with lower energy are kept alive.

The model of the WSN must catch the energy utilization and dispersion in the network. The model of a hub (for example modelling handling and correspondence) is identified with energy utilization and capacity and the earth model is identified with the energy creation.

### 3.3.2.. State Update of Algorithm

This algorithm goes for powerfully discovering economical courses in a multi-jump remote sensor network with energy reaping [17]. A course is feasible if energy of hubs along the course isn't depleted. It is accepted that the put away energy in a hub is quantifiable and through the progressions of put away energy it is conceivable to ascertain the utilization and generation of energy.

To ascertain an economical course to sink, data about both accessible energy and most limited separation from any hub to sink is required. The routing algorithm has two sections where one discovers every most limited way/separations to sink and the different applies remove punishments on ways to make up for lower energy accessibility.

The computation of the briefest separation can be performed with a few distinctive existing algorithms, for example, Directed Diffusion and separation vector routing all in all. Such an algorithm deals with the basic data of the network. Moreover it deals with hubs being brought into or expelled from the network. A precedent network is appeared on Fig. 4.3, where the network structure is appeared on the privilege and the separation to sink is appeared on the left diagram.

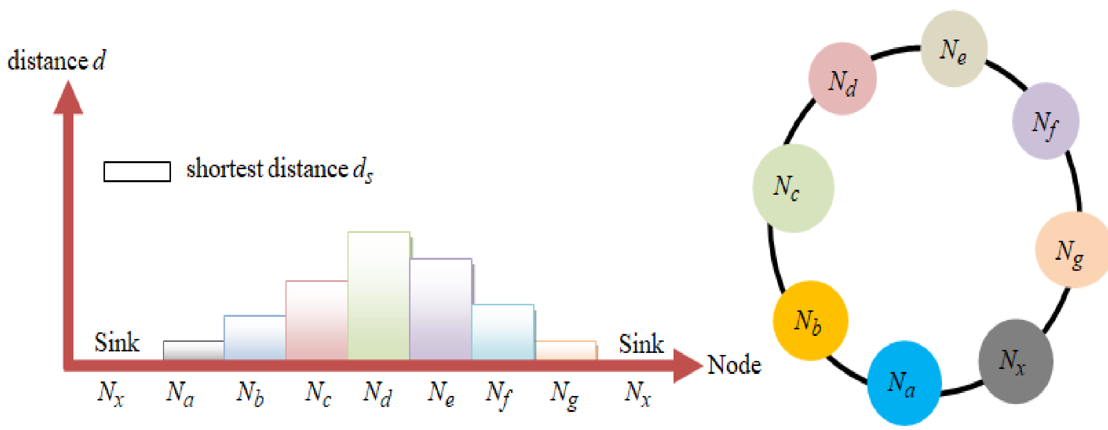


**Fig. 3.2: -** An example network displaying the shortest distance to sink.

### 3.3.3. Energy Information Encoding

The briefest way to sink is certainly additionally the least energy expending way to sink. This way does, be that as it may, not think about how much energy is accessible along this way or some other way.

To include energy mindfulness the accessible energy e : E in a hub must be estimated, Where E ∧ = [0; 1] (standardized as for the energy stockpiling limit C).

At that point it is changed over into a separation punishment f : E → D where D ∧ = R≥0.

For any hub, this separation punishment is a nearby separation punishment, for that hub.

To be significant, f ought to be monotonically diminishing, where the perfect circumstance is that f methodologies zero when there is a lot of energy, for example f (e) → 0, when e → 1, and f approaches endlessness when there is absence of energy, for example f (e) → ∞, when e → 0. In a solid WSN these perfect circumstances must be approximated.

All hubs are educated about their neighbors' separations to sink (counting punishments) and pick the most affordable/least expensive neighbor for routing. A separation including punishments is currently characterized as energy remove. Consequently the term most limited separation is barring any punishments while the briefest energy separation incorporates punishments.

***Algorithm1: State Update of Routing Algorithm***

*Input: x*

*1: if x is a local energy update then*

*2: A3(fpl(x)) {Energy availability, penalty update and broadcast}*

*3: else if x is a penalty update from a neighbour then*

*4: A2(x) {Penalty (from neighbour) and route update}*

*5: A3(dl ) {Distributed penalty update and broadcast}*

*6: end if*

### 3.3.4. Distributed Distance

Constrained energy accessibility is presently connected to the model network. This outcomes in nearby separation punishments to the hubs Ng and Nf. In this specific model there is a nearby least separation to sink at hub Ne. This is bothersome as Ne has no neighbor to whom it would be (based on the energy remove with nearby punishments) regular to send bundles to.

The circulated separation punishments are intended to take care of the issue with neighborhood minima which the nearby separation penalties can make. Each hub conveys changes in their energy information to its quick neighbors. Each time a hub gets an update from a neighbor, it checks in the event that it is in a nearby least. Provided that this is true, it increment its dispersed separation punishment to solve the issue and reports this to its neighbors through an update.

This procedure likewise works the a different way, hub checks whether its conveyed separation punishment is irrational high and brings down it suitably. In the model network, the conveyed separation punishment is currently included. It will currently show an algorithm which depends on these thoughts

Every hub runs a similar arrangement of algorithms to deal with the nearby and conveyed separate punishments. These algorithms deal with a lot of factors which comprises the condition of a hub.

It additionally deals with a duplicate of the condition of every neighboring hub. Besides it is expected that every hub utilizes a similar neighborhood separate punishment work f p l: E → D.

In view of that data the neighbor Nr, with the most brief energy separation to sink, is found.

Note that the nearby and circulated punishments are converged into one absolute punishment before it is conveyed; consequently just the all out punishment of a neighbor is known to a hub. The states $d_s$ and $d_{si}$ are overseen by an algorithm for finding the briefest basic separation and is hence not changed by this algorithm.

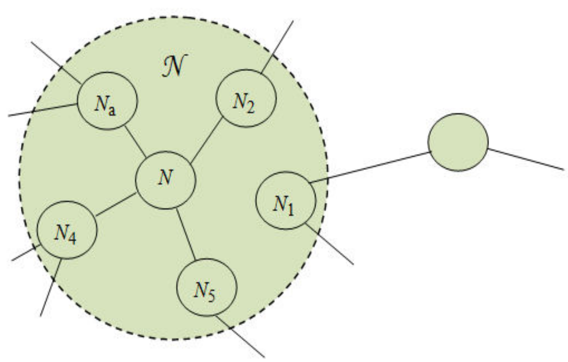


**Fig. 3.3:** Node and its neighborhoods

The algorithm is separated into three sections, a principle part A1, and two sub parts A2 (nearby punishment and route update), and A3 (disseminated punishment update and communicate) portrayed in the following three passages. The principle A1 is shown in Algorithm 1. It responds on an information occasion x. This occasion can either be a punishment update originating from one of the neighbors of N or a nearby energy update. On the off chance that the occasion is energy update (line 1), the deliberate energy is changed over to a neighborhood distance punishment through $f_{pl}$ and go to A3. On the off chance that the occasion is a punishment update (line 3), the occasion is passed to A2 and A3 is called with the present neighborhood distance punishment.

***Algorithm 2: Distributed Distance***

*Input: d0l: D*

*1: Δd1 ← dsr+ dpr− (ds + d0l+ dd) {energy distance diff.between Nr and N}*

*2: if (dd + cd) > −Δd1then {Ensure it always hold that dd ≥ 0}*

*3: d0d← dd + cd + Δd1*

*4: else*

*5: d0d← 0*

*6: end if*

*7: Δd2 ← d0l− dl + d0d− dd{local distance to sink change}*

*8: if −Δd1<cmin∨Δd2<clower∨Δd2>craisethen{Determine whether to update state and broadcast the update}*

*9: dl ← d0l*

*10: dp ← d0d*

*11: broadcast (dl + dp)*

*12: end i*

An adjustment in network structure is characterized as a change to ds and thus dsi in all neighbors. Such a change can influence the appropriated distance punishments in the network, however not the neighborhood distance punishments. In this way the conveyed distance punishment must be refreshed for all hubs that are influenced by the auxiliary change.

A quest for the neighbor with the most brief energy distance to sink will dependably work effectively. Contingent upon the algorithm utilized for finding the most limited auxiliary distance to sink, it may be conceivable to upgrade this computation like the methodology in Algorithm [18]. The expense of circulating the new dispersed distance punishments are not huge, since they will generally pursue a similar example as the basic updates and they can be converged into one transmission conveying both punishment and auxiliary update.

## 4. PERFORMANCE EVALUATION

The performance of the proposed system is evaluated under the scenario of the networks consist of 100 nodes, 200 nodes, 300 nodes, 400 nodes and 500 nodes distributed randomly in the area of 100m x 100m. The base station (50 m, 150 m) is positioned. The initial energy of all nodes takes the value of 0.5 J. This value is commonly used in the literature because it provides sufficient energy to quickly see the effect of application mechanisms. Each node sends a 2000 bit message per round to its cluster head. P is set to 0.05; about 5% of the nodes in a round are cluster heads.

The proposed EECROS-EHWSN reduces energy efficiency and takes into account potential parameters for a cluster head election, where 2-hop coverage is provided for each cluster head communication [19]. The results demonstrate that the EECROS-EHWSN makes WSN longer to operate than other approaches. The following parameters are used to compare the proposed approach and the existing one.

**i) Network Lifetime**

The time interval from the start of the operation to the death of the last living node. It is a combination of the stability phase and the instability phase.

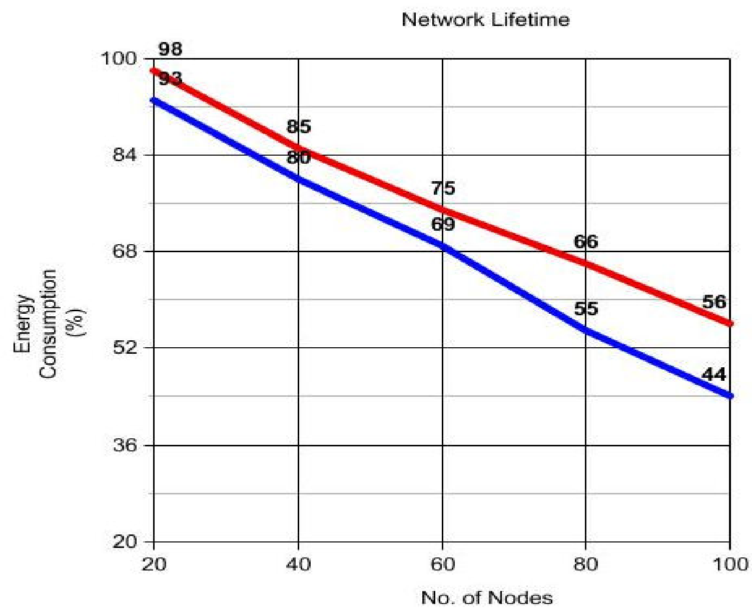


**Fig. 4.1: -**Network Lifetime

The result shows the efficient use of energy in the network and network lifetime is illustrated.

**ii) No. of CHs per round: -**

This Immediate action reflects the number of nodes this will send the data directly to the base station.

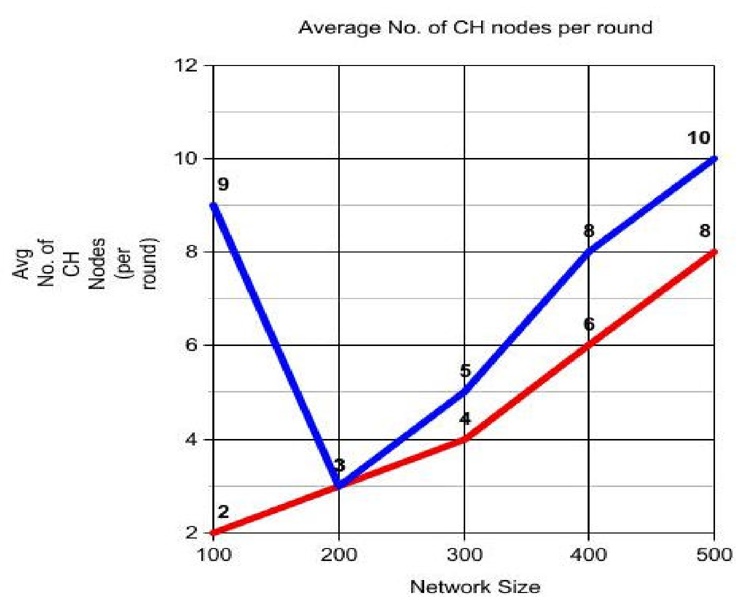


**Fig. 4.2: -**Average No. of CH nodes per round

The results show that EECROS-EHWSN outperformed LEACH for most of the cases. EECROS-EHWSN showed better scalability in more than 90% of the networks under test. This is because EECROS-EHWSN uses a larger number of CHs that cover the network.

## 5. CONCLUSION

In this paper, we have focus on two things, that is, prolong the network lifetime and quality of data transmission between the nodes and the base station. This can be achieved through the energy harvesting based wireless sensor network. Here, we propose an hierarchical energy harvesting adaptive fuzzy routing algorithm, referred as EECROS-EHWSN, to address the fuzzy based cluster head selection and also introduce the UDQ data compression technique to reduce the amount of data transmission between the CH and base station. The results declared that the proposed system improves the network lifetime and achieve the quality requirements of the network.

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