ZEEHC: Zone-Based Energy Efficient Hierarchal Clustering Hierarchy for Wireless Sensor Networks

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Abstract- Wireless Sensor Network (WSN) is an emerging technology with potential applications in the field of habitat monitoring and industrial applications. Sensors monitor changes in an environment's physical attribute such as temperature, and observe the data collected and forward it to the base station (BS). Mostly these sensors are unattended, and their limited battery life makes energy a valuable resource that has to be used wisely. For the collection of information, the sensor network must be maintained for a longer duration of time in an energy-efficient manner.Therefore, designing protocols that prolong the life of the network and which are energy-efficient is incessantly fascinating. This paper proposed a protocol referred to as the zone-based energy-efficient hierarchical clustering (ZEEHC) protocol that divides the network into small zones and increases network lifetime. In order to achieve minimum energy consumption, multi-hop contact is implemented between ZHs - CHs -BS. The results further reveal that the proposed protocol significantly outperforms existing algorithms in terms of energy optimization and system lifetime.

1. Introduction

WSN is basically a group of wireless nodes that have limited energy capabilities and are placed at random on an energetically varying environment. The selection of routing strategies is a vital problem for delivering the packets to the sink effectively. In addition, the routing strategy implemented in these networks must ensure the minimum energy consumption to optimize the lifetime of the network[1].

The problems of the network lifetime and availability of data are crucial in WSN because they are deployed in an unsympathetic environment[2]. The operation of the sensor network takes place in different stages such as planning, deployment and operation and at last action[3].The *planning stage* consists of conducting of survey of the site in order to examine the environment and the circumstances for the selection procedure in the implementation mechanisms. *Deployment stage* consisting of the randomly deployment of the sensors in the sensing area. Following the deployment stage require *sensor network administrator* for the evaluation purpose where sensors to approach more coverage. *Operation stage* includes proper functioning of maintaining projects, sensors inspect environment and provide information. *Post operative stage* includes powering off and safeguards sensors for upcoming functions and to destroy sensor network.

The military and defense industries implemented the first WSN in the mid-70s. WSN is used during the Vietnam War to bear enemy detection in remote areas.But their implementations had many drawbacks including the large sensor size and higher energy utilization and the limited network capability.

Routing protocols are one of the key technologies in the WSN. Routing is a complete challenge in WSN [4], due to its intrinsic characteristics. Clustering is a well-know and generally used tentative data transmission technique, and is mainly useful for such applications that require scalability [5]–[10]. In clustering protocols, the entire network is subdivided into clusters having cluster members (CMs) and one cluster head (CH). All CMs transmit their sensed information to CH, which is responsible for long run data transmission to the sink. The energy consumption using clustering approach is much lower than the direct transmission. However, in clustering due to overburden at the CH due to long transmission of data, CHs die out earlier[11].

In this paper, we propose a Zone based Energy Efficient hierarchal Clustering (ZEEHC) protocol to maintain the energy utilization among all nodes. The WSN is divided into equal size of zone. ZEEHC helps to improve the network lifetime with low utilization of energy in the WSNs. The clustering protocols are actually contains cross layering techniques for scheming energy efficient hierarchal WSNs [12] where the nodes that belong to a CH gives their data to the CH and then CH gives aggregate data to the relay node in the zone. The aggregated data is then transmitted to BS by relay node using multi-hop communication. The clustering schemes can raise network lifetime and better energy efficiency by decreasing all of the energy consumption and maintaining utilization belonging the nodes during the network lifetime [13], [14]. The clustering protocols are explained according to the schemes they accept to select CHs as well as communicating the aggregate information to the sink[15], [16].

2. RELATED WORK

Energy efficient design and the latest wireless technology for wireless devices, described by Heinzelman et.al[17]. Various types of applications covering a large area, along with real-time cascade audio and video distribution, to transfer large amounts of data from one device to another. The above applications containgreat achievement in the ring, it often endure from ability restrain.Wireless devices often have limited intensity resources, because the nodes are battery operated. This makes the program with limited bandwidth by making a transmission error prone. WSN subsist of a set of sensor nodes empower the control of an assortment of settings for applications. In WSNs, it is very relevant for sensor network for a long time. In this case, integration of data useful to diminish the bulk of information transferred among nodes of sensors and BS[18], [19].

There are many different types of energy efficient clustering protocols designed among cluster based network frame. The LEACH[11] protocol defines energy utilization is same in all the nodes during selection of cluster heads. In this protocol,the non-cluster heads gives their data to nearest CH and CH forwards the aggregated packet to sink. In LEACH protocol,CH decision basically depend on the percentage of CHs for the network (resolute on priori) and the number of time that node has been CH so far. This evaluation is taken by the node n by selecting a random number between 0 and 1.If the selected number is less than a threshold $T(n)$,the node become Ch for the current round. The Threshold is as:

$$T(n) = \begin{cases} \frac{p}{(1-p*(r \bmod 1/p))} & if \, n \in G \\ 0 & otherwise \end{cases} \tag{1}$$

The CH forwards the accumulated data to the sink or destination. LEACH incorporate random shot orbit of high-intensity CH location with the sensor to escape exhausting the lifetime any sensors in the grid[20], [21]. The problem is that when the data collection process does not give the size reduction outgoing data, clustering can propose additional power utilization and a lag in the information assemble process[22]. LEACH works well with fully fusible and partly fusible data. But, more emphasis is made on energy consumption and collection efficiency is neglected.

The HEED protocol using a multi-hop communication scheme in which CH selects according to the residual energy as well as lower power stage required by a node to transfer the information with its CH and CH gives their data to base station [23].

In EECS, aggressive allotment of clusters takes place which is established on cluster distance from the main station. The conclusion is an innovation that dwelling the obstacle that clusters at a highest distance from the sink lack more power for communication than those that are nearest. Basically it contribute same dissemination of power in the networks, appear in network lifetime. SEECH is a scalable energy efficient clustering hierarchical protocol which employs a hierarchal clustering. In SEECH, divide area into three regions as well as all the nodes are randomly deployed in a given regions. After that we calculate degree of nodes(degree means distance between each node according to region).If the probability of tentative cluster head (P_{ci}) and relay head (P_{ri}) is less than random value on the basis of degree of node can be selected as tentative CH and relay head. If the probability of tentative CH and relay head is greater than random value than calculate the score of all nodes (score is defined as product of distance of all the nodes from their respective cluster head and relay head) and nodes having minimum score select as actual cluster head and relay head. SEECH is a scalable energy efficient clustering hierarchical protocol which employs a hierarchal clustering. In SEECH, divide area into three regions as well as all the nodes are randomly deployed in a given regions. After that we calculate degree of nodes(degree means distance between each node according to region).If the probability of tentative cluster head (P_{ci}) and relay head (P_{ri}) is less than random value on the basis of degree of node, thenthese are selected as tentative CH and relay head. If the probability of tentative CH and relay head is greater than random value than calculate the score of all nodes (score is defined as product of distance of all the nodes from their respective cluster head and relay head) and nodes having minimum score select as actual cluster head and relay head.

$$P_{ci} = \begin{cases} ((E_{resi} \times \deg i)/pc - tot), & Eresi \geq Eav \,(1 - \lambda) \\ 0, & otherwise \end{cases} \tag{2}$$

$$pc - tot = ((Eav \times \textstyle\sum N \deg i)/2K_{CH}) \tag{3}$$

$$P_{ri} = \begin{cases} ((E_{resi} \times \deg i)/pr - tot), & Eresi \geq Eav \,(1 - \lambda) \\ 0, & otherwise \end{cases} \tag{4}$$

$$pr - tot = ((Eav \times \textstyle\sum N \,(1 - \deg i))/2KR) \tag{5}$$

3. Energy Dissipation Radio Model

The first form of radio model for WSNs is used which is presentedin Fig.1.Only the free space canal model is used for the experiments described here. Thus the radio expends energy to transmit$l$-bit message a distance d:

$$E_{TX}(k,d) = k * E_{elec} + k * E_{rs} * d^2 \quad d < d_o \qquad (6)$$
$$k * E_{elec} + k * E_{amp} * d^4 \quad d \geq d_o \quad (7)$$

The first term represents the power consumption radio distribution, while the other represents the energy consumption for extreme Radio model. Appropriate space E_{fs} and multi-path fadingE_{amp} channel model depends on transmission distance. When receiving this data, radio spend

$$E_{Rx}(k) = k*Eelec \qquad (8)$$

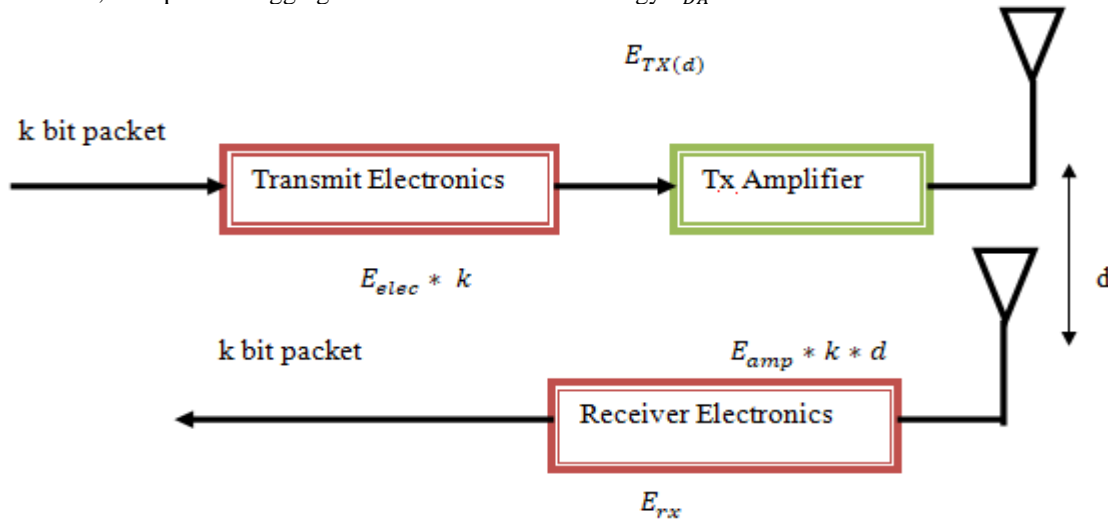In addition, the operation aggregation of data will absorbenergy E_{DA}.

Fig1 First order radio energy model [16]

4. ZEEHC PROTOCOL

This work is motivated by EEHC protocol which is extended to an enhanced version of EECH. Basically, in this work a new zone based scheme introduced based EEHC protocol is introduced for WSNs to increase network lifetime and stability period. In LEACH protocol, CHs get changed in every round and after cluster formation, those CHs don't get chance to become CHs for next 1/p rounds. In our proposed work, we introducing modified EEHC as CH selection technique in the presence of Zone. It introduces combined threshold parameter in cluster formation for CH election in every upcoming round. This is how we can store more energy consumption on CH election and cluster formation processes.

In ZEEHC, area divided into zone and distributing the nodes in network area. Basically, we present a technique to reduce the energy dissipation and prolong life of the network. Therefore, the subsequent changes have made in the SEECH protocol to improve the adaptability and better the network lifetime.

Model Architecture and Basic Assumptions
- Number of nodes is 100, 400, 1000 in the network for three scenarios.
- Homogenous network consist by WSN.
- The BS is situated outside WSN.
- Sensor nodes have same initial energy.
- All nodes can forward data to ZH.
- Data compression is done by ZH.
- In first node, exclusive node has probability *p* of becoming the ZH.
- Nodes with higher energy in previous round become tentative relay.
- Nodes which have minimum distance in previous round become RH.

ZEEHC Process

First of all network parameters are initialized. As the network consists of homogeneous sensors, all have the same initial energy before that sensor field is decided. After the deployment of sensors, rounds are started. In a given region ZH and RH selection occur on the basis of remaining energy of nodes in previous round and

distance from the BS. Then cluster member sends their data to the nearest ZH, data aggregated by ZH and forwarded to RH by using multi-hopping communication and then send to BS.

Zone Head Selection

In ZEEHC protocol, area is divided into number of zones and sensors are deployed randomly in a given network. Generally nodes having high energy are more appropriated selected for CH. The advantages of this technique is that high amount of nodes might be covered by less number of CH utilize low power data transmission. The method of selection of CH as follows. Firstly, normal node checks the maximum energy of previous node in previous round for new node and also identifies the minimum distance from BS is selected as a CH.

Relay Head Selection

The nodes nearer to the BS can helpful to reduce data communication cost. The protocol selects these nodes as CHs so that energy is stored for information transfer to the BS. The nodes having larger intra-cluster energy utilization those nodes cannot be a CH. For maintaining energy utilization, large amount of energy utilization tasks should be given to exclusive node during network lifetime. Since, in this protocol relay nodes are selected on the basis of energy and distance from BS. Firstly, in previous round energy of new node is high than the energy of previous node and distance of new node is less than the previous node from BS mainly selected as relay node.

In ZEEHC nodes are randomly deployed and in exclusive zone one ZH and one relay node is selected based on remaining energy and the separation from BS. In ZEEHC multi-hopping scheme also used for the data transmission to sink. Let it to be taking a particular threshold value if the energy of CH is higher than the threshold value then CH node directly transmit the data to the BS. If the energy of CH is less than the threshold value then it firstly transmits the data to the nearest relay to next relay, so multi-hopping is done during this proposed scheme.

Algorithm 1: Zone Head Selection Algorithm

1.   No. of zones=n
2.   Divide into for equal zone
3.   for (zone=;zone>=n; zone++)
4.   Deploy sensor node each Zone
5.   end for
6.   *While (normal node = dead node)*
7.   // Relay selection
8.   For (zone=;zone>=4;zone++)
9.   *If (check node for Maxi. Energy in Previous node)*
10. Tentative relay node   ◄New Node
11. *If (New node Distance from B.S is mini. Previous round)*
12. Relay Node   ◄New Node
13.   *end if*
14.   *end if*
15.   // Selection of Zone head
16. *If (Energy of New node = max. energy of Previous round)*
17.   Normal Node ≠ relay Node ;
18. *If (New node Distance from B.S < Previous ZH node Distance from BS)*
19.   Normal Node   ◄New Node ;
20. *end if*
21. *end if*
22. *end while*
23. // ZH aggregate data sends direct from Node to the data and send to zone relay node
24. Relay node tx. data to BS using multi-hopping to other relays.
25. // check for alive and dead node
26.   If(Energy of node < 0)
27.   Dead node =dead node +1;
28. end if
29. *Total Alive node = Alive node –dead;*

Proposed Algorithm

The flowchart for the operation of ZEEHC is shown in Fig. 2. There are five phases which describes the process of our proposed scheme ZEEHC. In this, each round repeats periodically having differentphases, as follows:

1.   **Initialization phase:** In the first phase, there are two steps involved. First step is to initialize network parameters. Network parameters are area, rounds, nodes etc are initialized. Second step is to deploy the sensors randomly in the given area.

2.   **Statistics phase:** This phase gives information about the dead nodes, alive nodes, first node dead, average node dead node dead, last node dead etc.

3.   **Selection phase:**In this phase,ZH and RH is selected on the basis of some sensor node concepts like residual energy, distance from BS, distance between node to ZH, connection time and the number of rounds that the node n was selected ZH so far.

4.   **Association phase:** After selection of the ZHs in the current round, once each non ZH receives the information from the ZHs, it determine its cluster by choosing one of the ZHs with minimum distance. In this way, nodes get associated with their corresponding CHs.

5.   **Energy consumption phase:** In order to calculate energy dissipation, the first order radio model is used and its parameters are used. The energy consumed during node to ZH communication, ZH transmission and reception are being calculated.
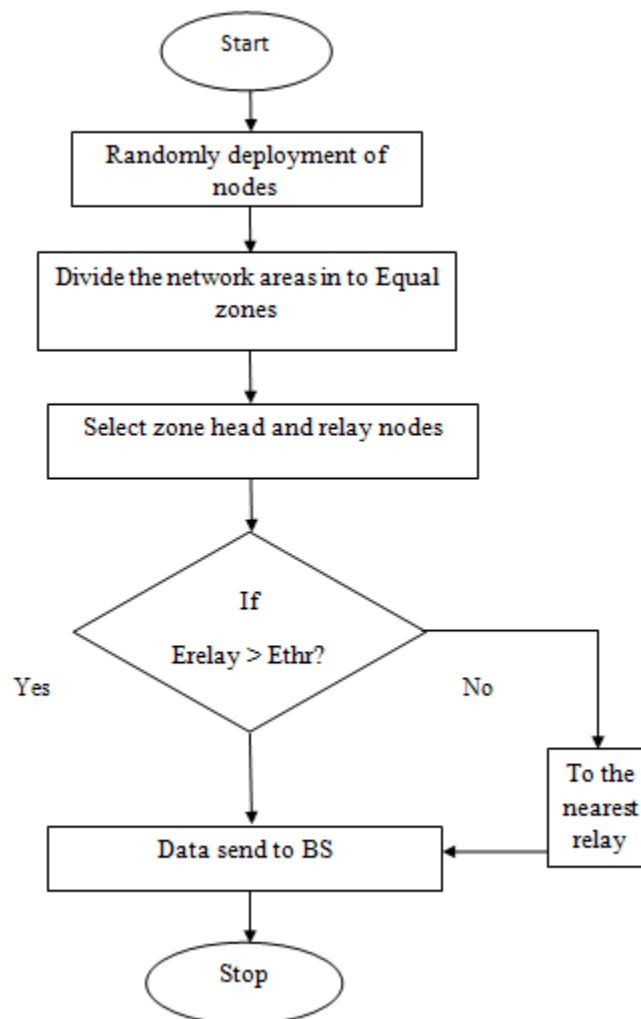

Fig. 2 Flowchart for the operation of ZEEHC

5.   V. Results and Discussions

Energy efficient deployment is not an easy task due to the large number of parametersi.e.energy parameters, then selecting the CH for the transmission processand their data. MATLAB programming platform is used to

encode the SEECH and ZEEHC. The performance of ZEEHC is explained in terms of network lifetime and stability period against the SEECH protocol.The main objective of the ZEEHC is uniform energy distribution, ensuring that the network remains fully operational in the maximum amount of time. WSN's main goal is to field sensors, sensor node that works when used with requested information as equal to the energy consumption of each sensor is a fully functioning network is essential.

The proposed scheme is zone based energy efficiency protocol that improve network lifetime in three different scene1, scene 2,scene 3 with deployment shown in Figures 3-5 respectively.The performance of ZEEHC is compared to SEECH protocol in three scenarios. Table 1 defines the parameters of proposed scenes in details. A comparison of the number of alive nodes in scene 1, scene 2, and scene 3 for SEECH Protocol and ZEEHC Protocol is presented. The CHdistribution is needed in clustered WSN application.

Table1 Simulationparameters used for ZEEHC

| Parameter	Scene 1	Scene 2	Scene 3
Area	(0-0),(100-100)	(0-0),(100-100)	(0-0),(100-100)
Number of nodes, N	100	400	1000
Initial energy of normal node, E_0	0.5J	0.5J	1J
Transmission range within cluster		87m	
Radio electronics energy,$E_{Tx}=E_{Rx}$		50 nJ/bit	
Radio amplifier energy, $\mathcal{E}_f$		10 p/bit/m^2	
Radio amplifier energy,$\varepsilon_{two\_ray\_amp}$		0.0013p/bit/m^4	
Energy for data-aggregation, E_{DA}		5 nJ/bit/signal	
Data packet size		4000 bits	
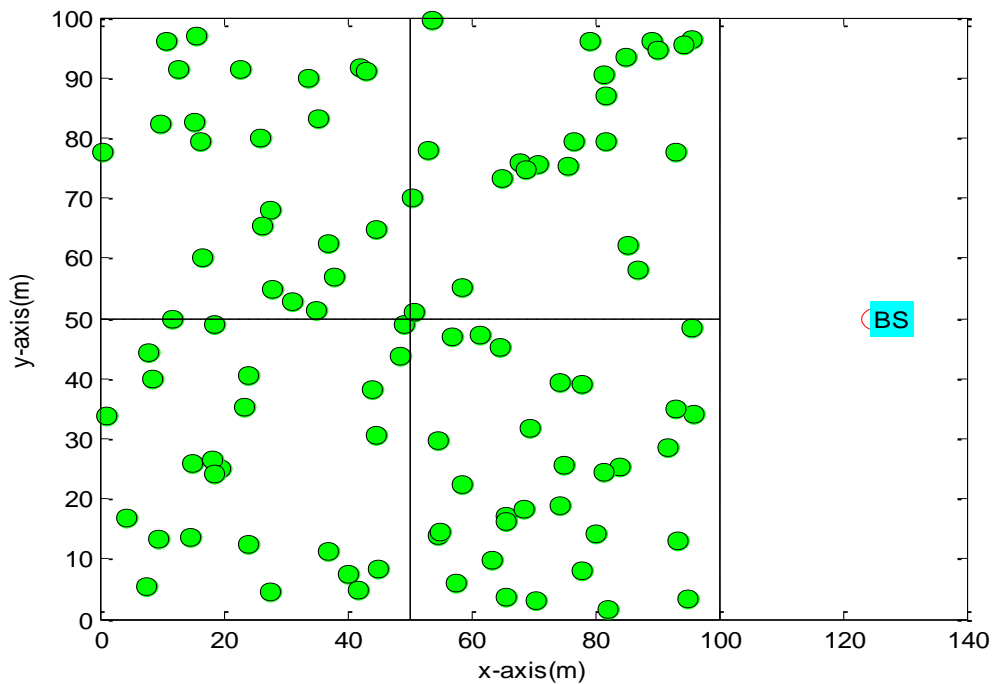
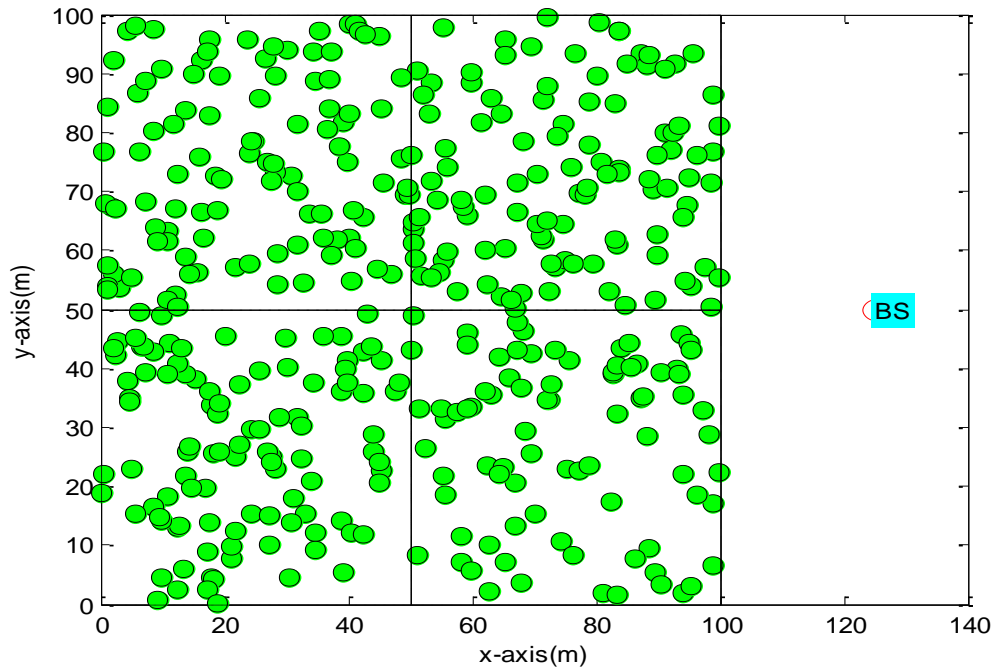**Fig. 3** Deployment of ZEEHC for (Scene 1) 100 nodes

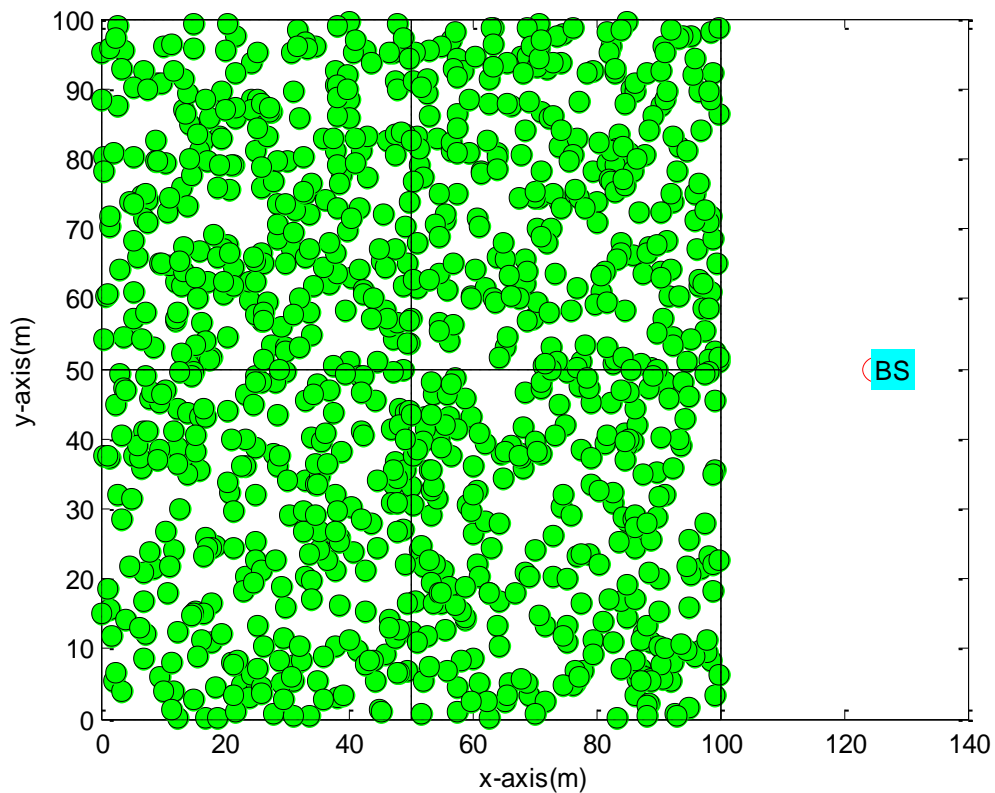**Fig. 4** Deployment for ZEEHC (Scene) 2 for 400 nodes

Fig. 5 Deployment for ZEEHC (Scene 3) 1000 nodes

In ZEEHC protocol multihop communication scheme is used. In this scheme cluster member send their data to their nearest ZH (denoted in blue color) in which ZH is elected based on remaining energy and the minimum distance from the BS. After receiving data from cluster member, ZH aggregate the data and send to Zone relay node (denoted in red color), then relay node transmit the data to BS using multihop to other relays which is shown in figures 6-8.
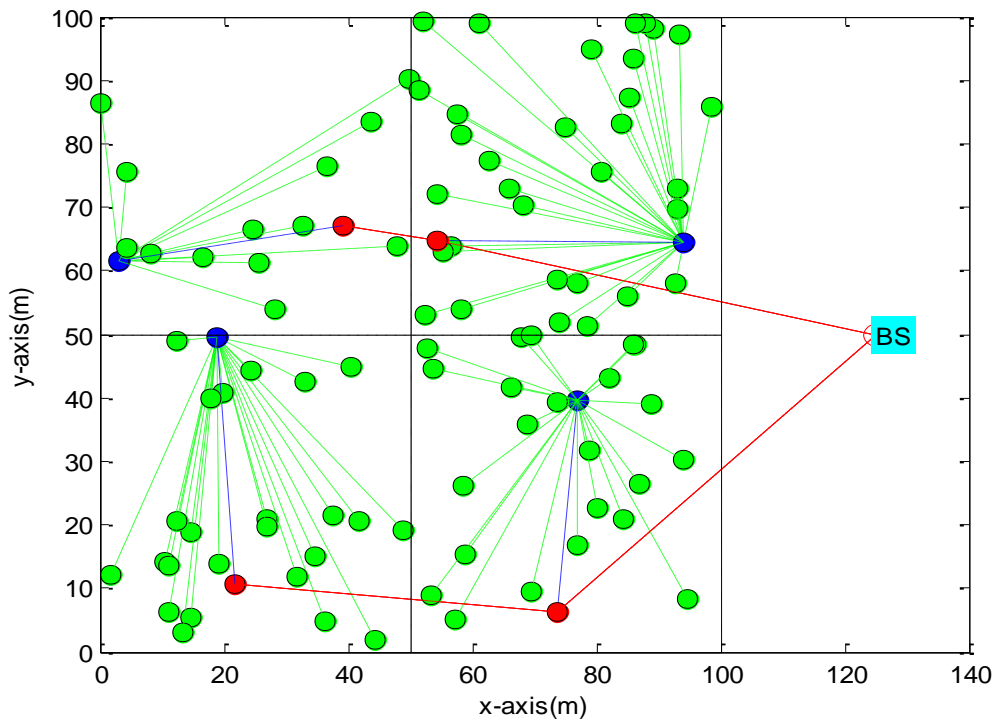
Fig. 6 Multihop communication in ZEEHC (Scene 1) 100 nodes
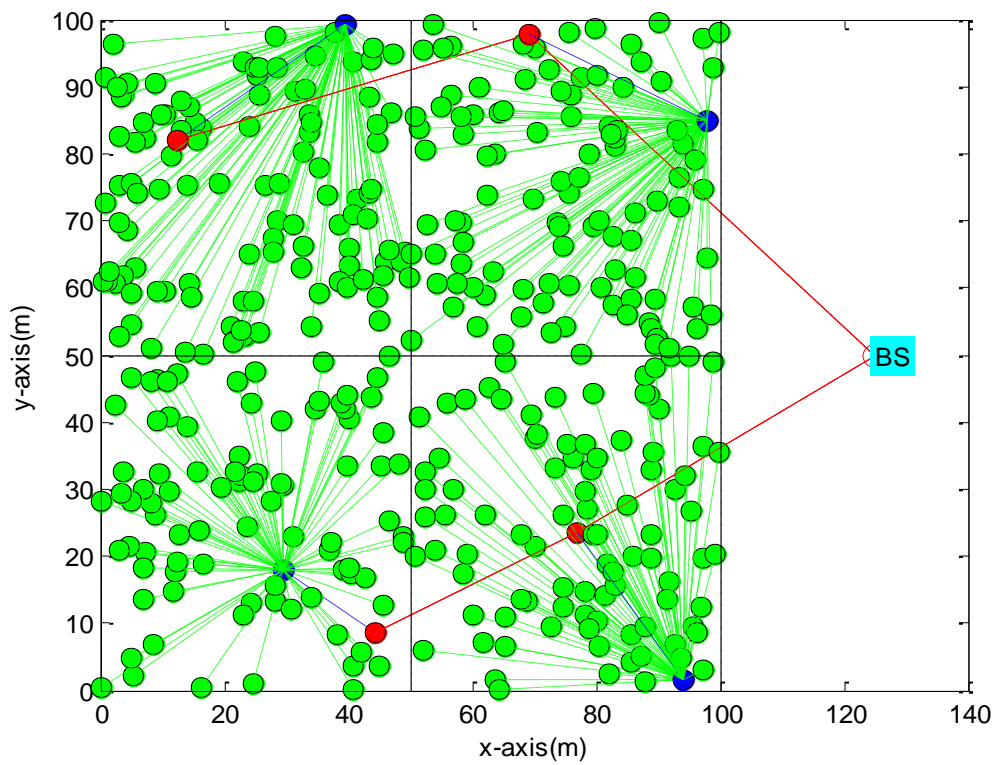
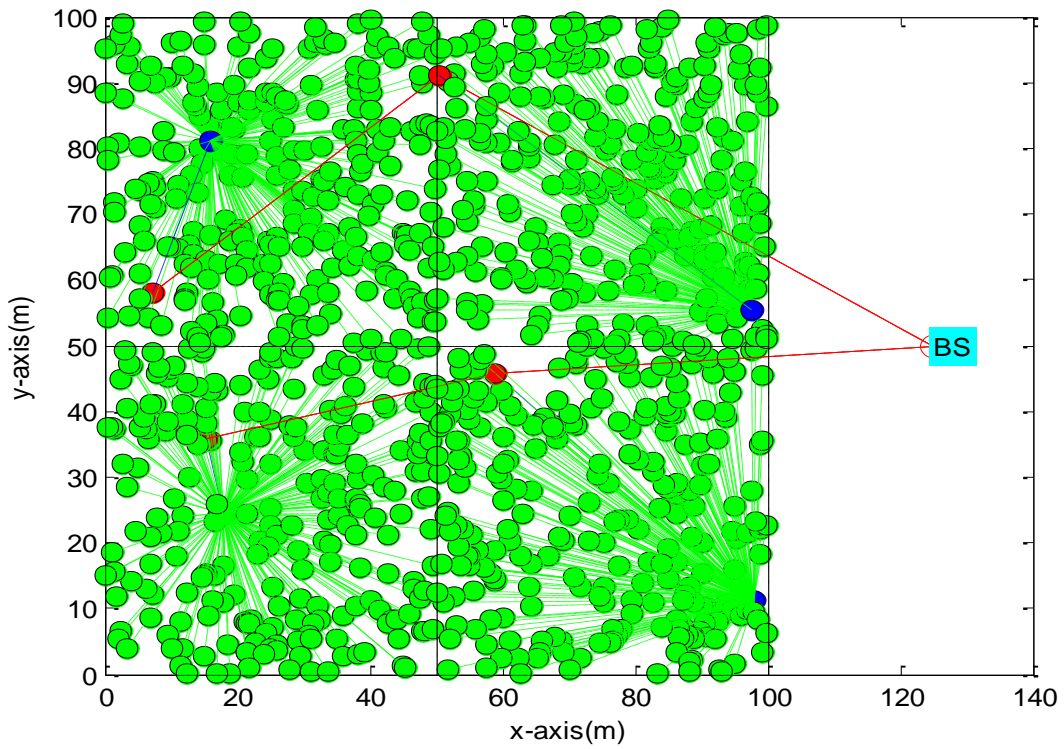**Fig. 7** Multihop communication in ZEEHC (Scene 2) 400 nodes

Fig. 8 Multihop communication in ZEEHC (Scene 3) 1000 nodes

A comparison of the number of alive nodes in scene 1, scene 2, and scene 3 for SEECH Protocol and ZEEHC Protocol is presented. Alive nodes are those nodes whose battery is not completely depleted. The evaluated results are shown in Figures 9-11 for different scenarios.
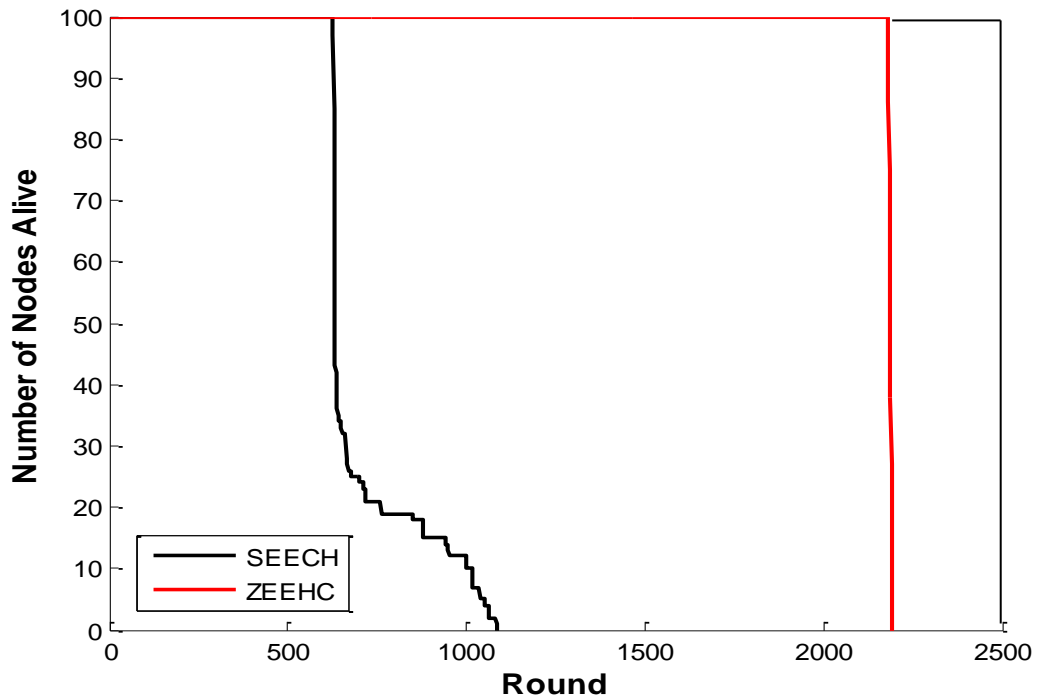

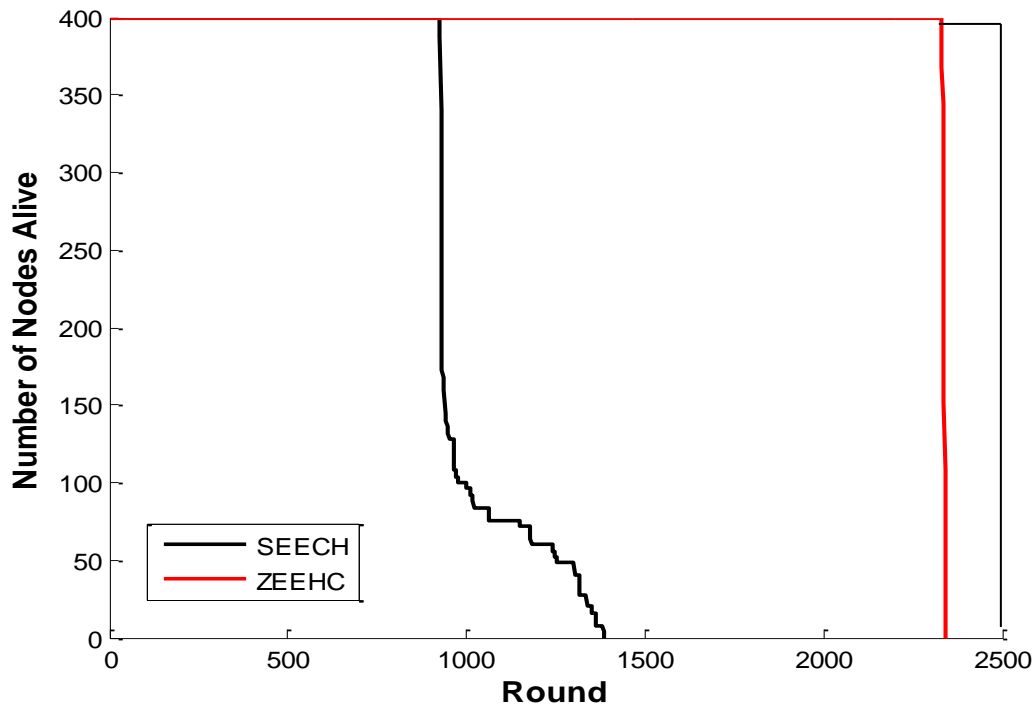**Fig.9** No. of alive nodes for (scene 1)100 nodes

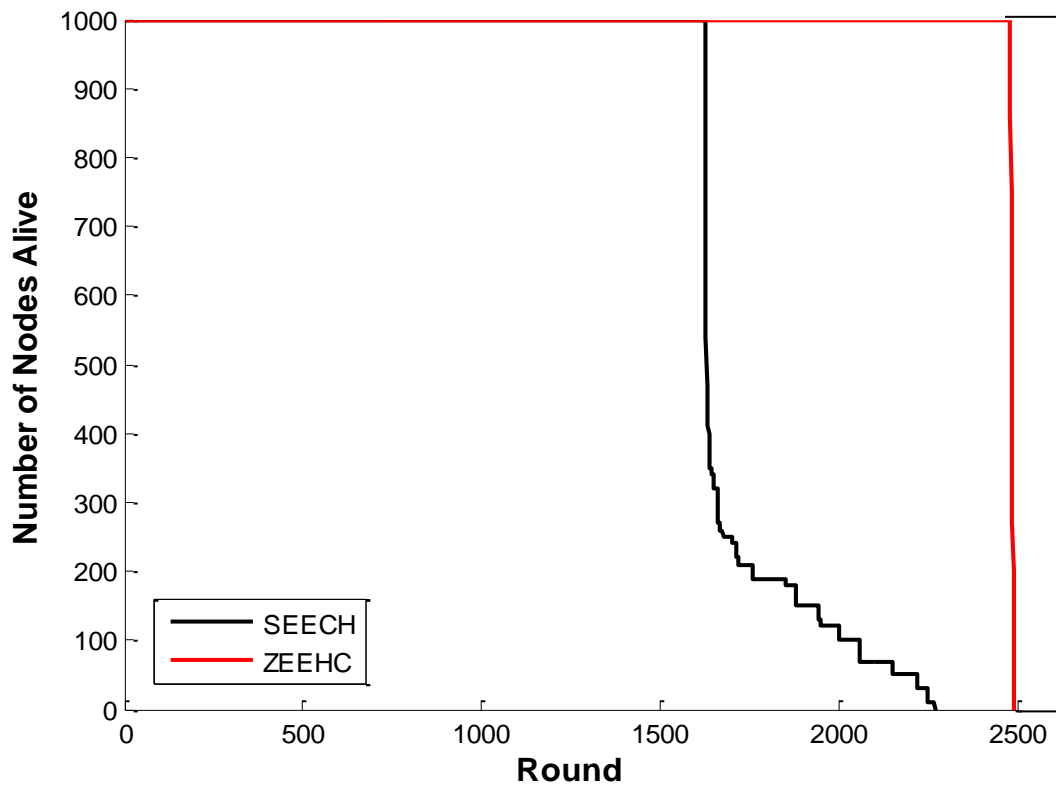**Fig. 10 No. of alive nodes for (scene 2) 400 node**

Fig. 11 No. of alive nodes for (scene 3) 1000 nodes

The CHdistribution is needed in clustered WSN application. The intra-cluster delay is maximum and proportionate to the size of the biggest cluster therefore maintaining cluster avoid increase of delay and avoid large-distant communication between CH and cluster member. To measure the quality of distribution for CHs we use energy dissipation as shown in Figures 12-14.
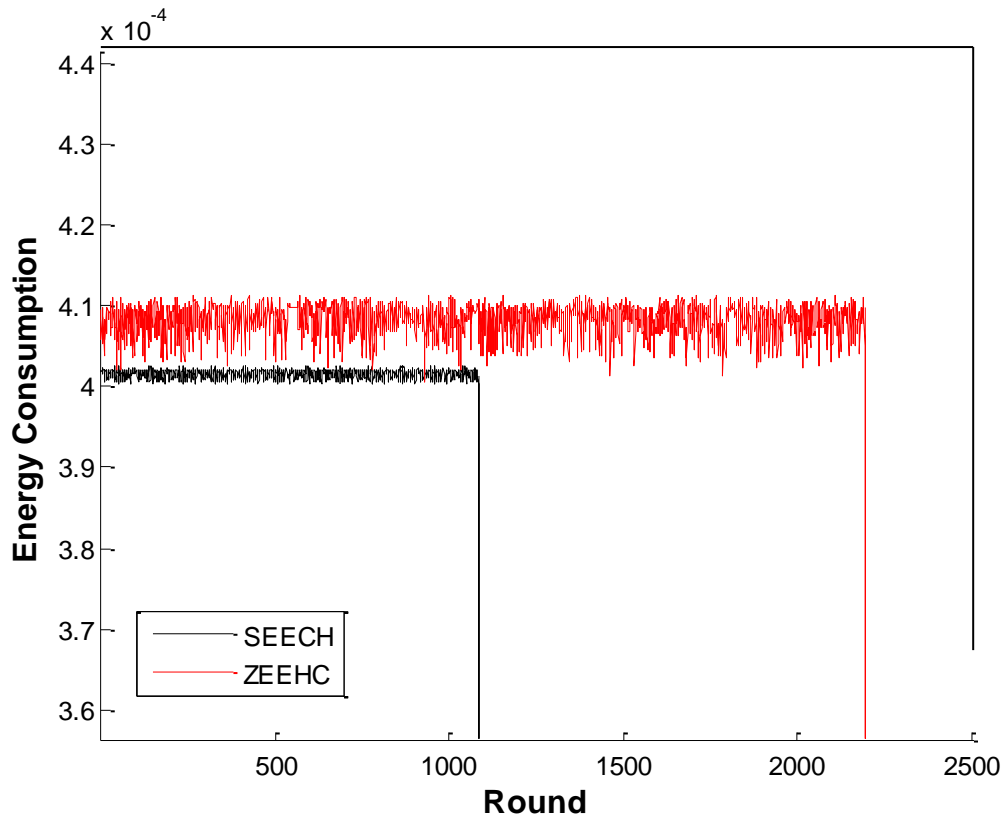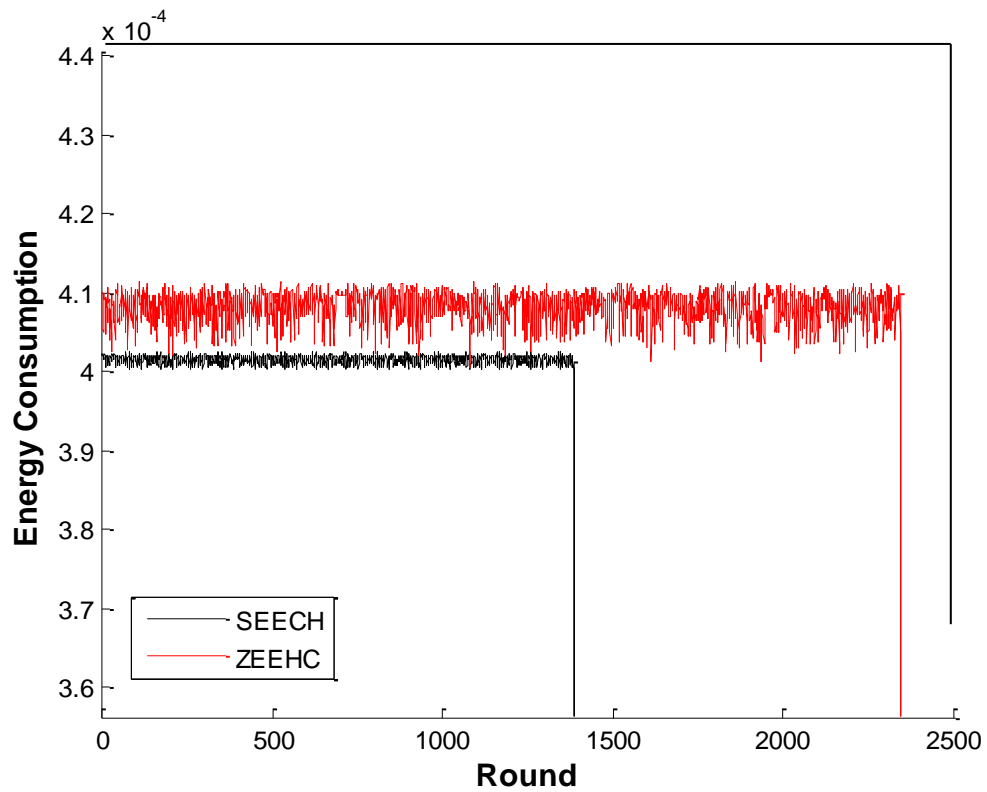
Fig.12 Energy Dissipation for scene 1(100 nodes)

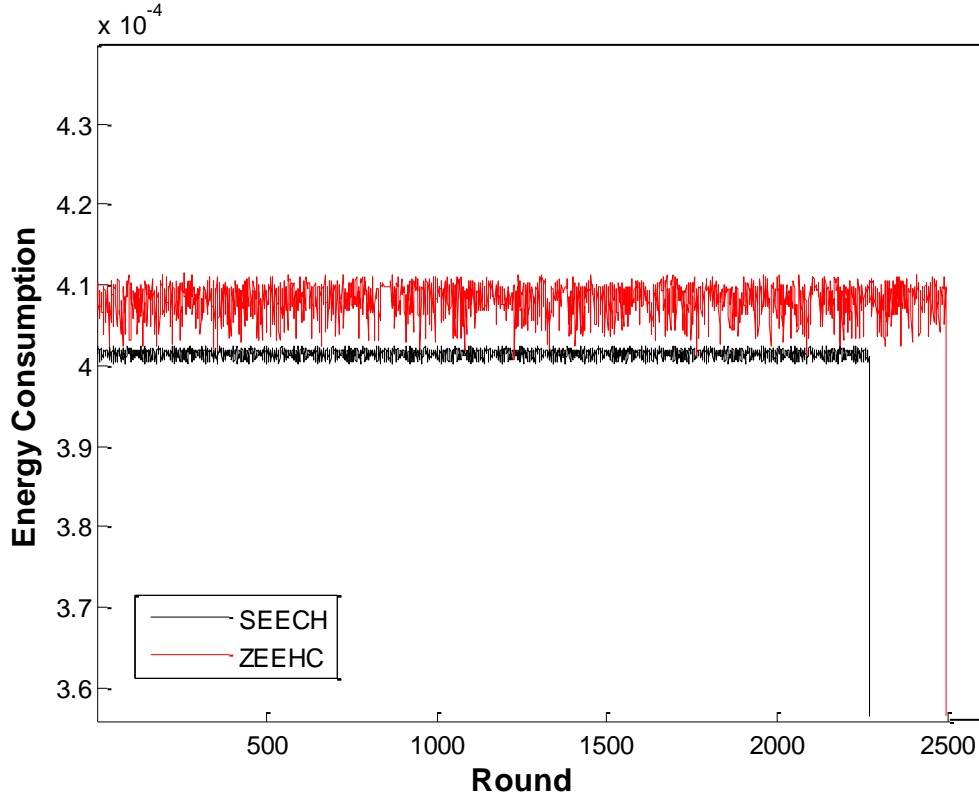**Fig. 13**Energy Dissipation for scene 2(400 nodes)

Fig. 14 Energy Dissipation for scene 3(1000 nodes)

We also compare the performance of ZEEHC against SEECH in terms of the first node dies (FND), the average node dies (AND), the last node dies (LND). Table 2 shows results on the basis of initial energy of nodes.In research work, three cases are considered for simulations of our proposed protocol ZEEHC which are given below:

Case1:100 nodes and location of sink (50,175)
Case2:400 nodes and location of sink (50,200)
Case3:1000 nodes and location of sink (100,350)

Table 2 Comparison between the lifetime of SEECH and ZEEHC in different scenes

Scene	Initial Energy	Protocol	FND	AND	LND
Scene 1 (100 Nodes)		SEECH	832	1248	1358
	0.5J	ZEEHC	1163	2066	2320
Scene 2 (400 Nodes)		SEECH	938	1347	1456
	0.5J	ZEEHC	1568	2105	2406
Scene 3 (1000 Nodes)		SEECH	1479	1710	1921
	1J	ZEEHC	2045	2368	2786

When any node in the network is dead, it is no longer the part of that network. This implies that if a dead node occurs in early rounds, it will affect the network performance. This may also lead towards the early dead of all the nodes in the network. In this simulation we have observed the first dead node by keeping the base station position at (100,200) with 4000 bits packet size. Table 2 shows the values and Fig. 15-17 conclude that ZEEHC is better compared to SEECH protocol.

Case1: In this, no. of nodes is 100 varying against no of rounds as shown in figure 15. Initial energy is 0.5J. The number of nodes in the network was varied and their effect on lifetime was considered.

Fig. 15 Performance results for FND, AND, LND for Scene 1

Case2: In this, no. of nodes is 400 varying against no of rounds as shown in figure 16. Initial energy is 0.5J. The number of nodes in the network was varied and their effect on lifetime was considered.
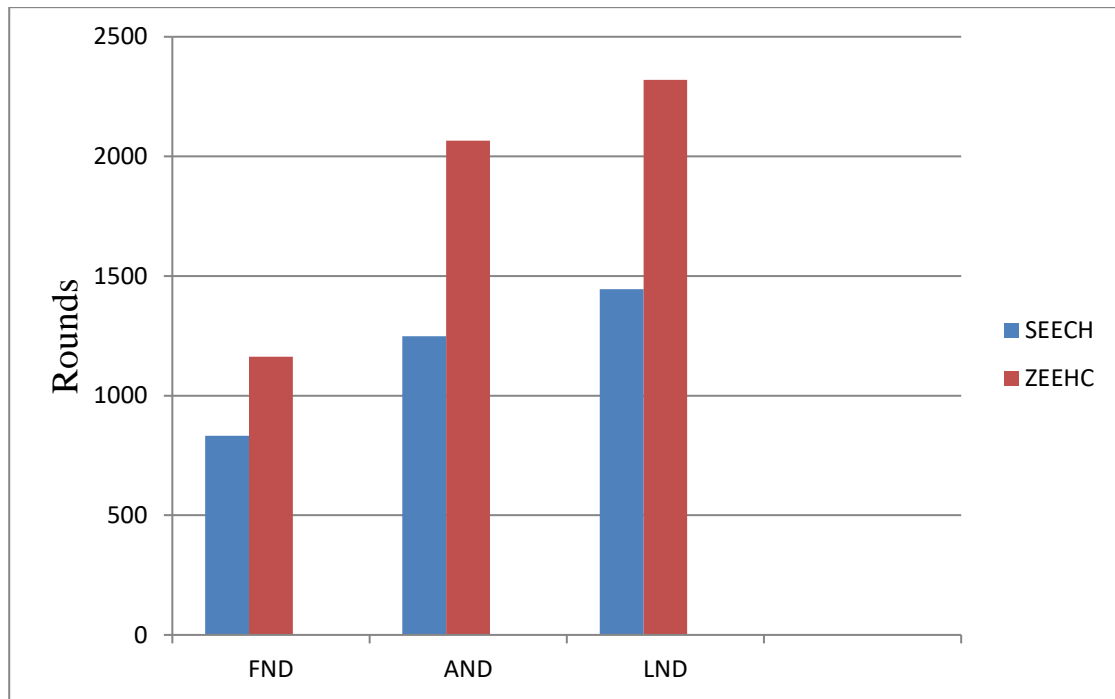

Fig. 16 Performance results for FND, AND, LND for Scene 2

Case3: In this, no. of nodes is 400 varying against no of rounds as shown in figure 17. Initial energy is 0.5J. The number of nodes in the network was varied and their effect on lifetime was considered.
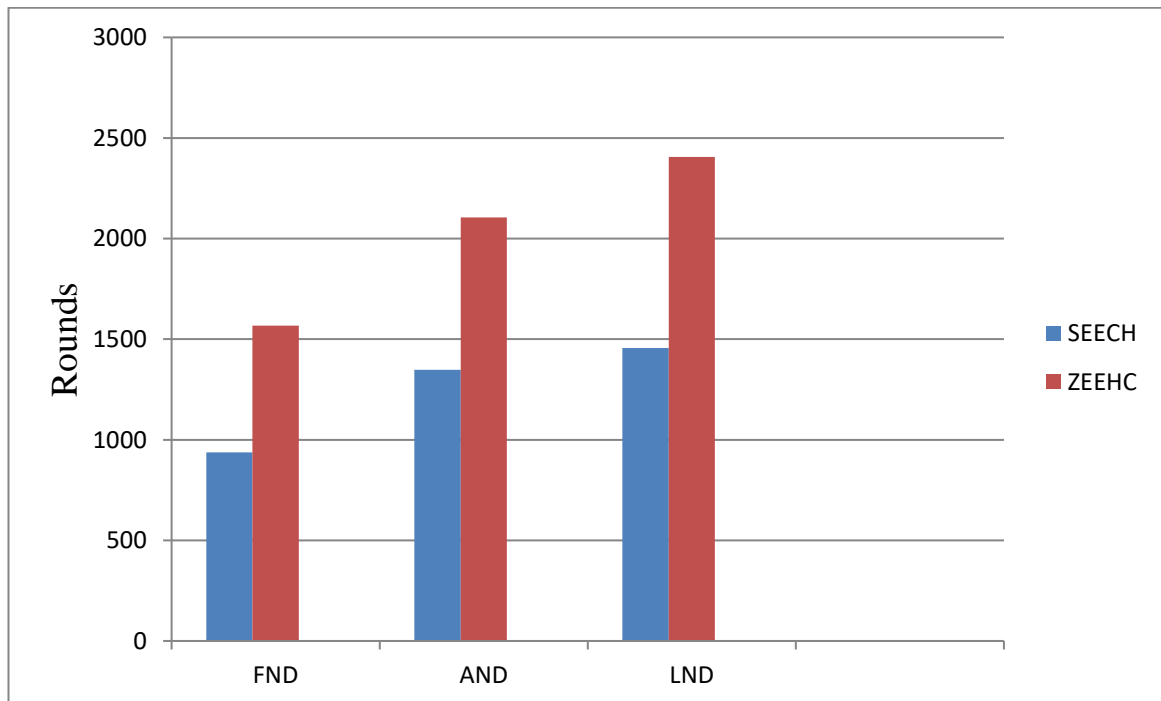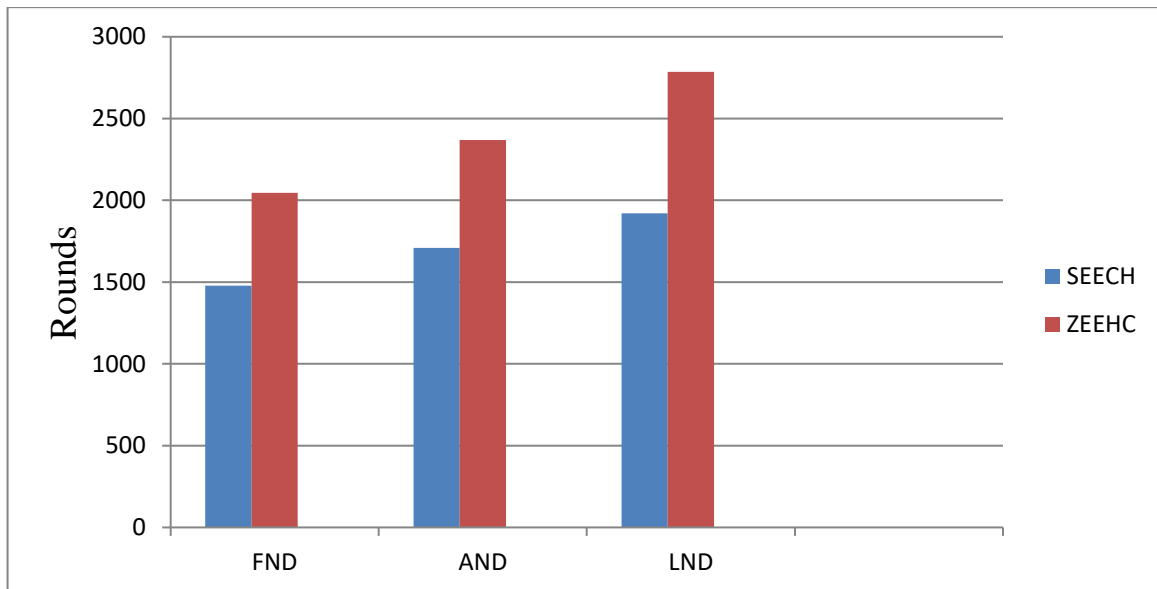
Fig. 17 Performance results for FND, AND, LND for Scene 3

6. Conclusion and Future work

In Smart Space and Extreme environment energy-aware distributed sensor monitoring and data clustering is relevant to save power. The important design issues in routing protocols are energy utilization [24]and network lifetime. A major challenge in routing protocol is to achievehigh stability period in order to preserve the coverage area.A zone based energy efficient hierarchy Protocol (ZEEHC) clustering is proposed in that the member nodes, cluster heads and relay are categorized differently within the network. ZEEHCdepicts a simple message of low overhead approach for periodic information accumulated applications in harsh and remote environments that extend network lifetime under three scenarios. The simulation outcomes showed that ZEEHC protocol achieves better lifetime than SEECH. Simulation results show that ZEEHC can be used for large scale networks. Adjacent improvement can be possible by considering nature inspired algorithm for   successful delivery of data.

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