IMPLEMENTING WIRELESS SENSOR NETWORKS ON WIDE AREA USING HETEROGENEOUS NODES

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Abstract : ***Various clustering techniques in Wireless Sensor Networks (WSNs) assume that all nodes will have same energy despite the fact that they are going to do different tasks. Thus the energy of nodes is not used completely. To counter this problem heterogeneous nodes have been introduced in which there are two types of nodes i.e. advanced nodes and normal nodes. Each one of them has different energy levels and the tasks which will be performed by them have been divided. Also pre-existing models works well on smaller area say 100 sq m. so when these approaches were applied on wide areas, results start to degrade. Thus to counter it mobile advanced nodes were used. A new protocol is proposed and results are than compared with pre-existing protocols. Simulation results show the new protocol works well on wide areas and maintains stability and efficiency of network.***

IndexTerms - Clustering, energy-efficiency, stability, wide area, heterogeneity, Wireless sensor networks.

INTRODUCTION

Wireless Sensor Networks (WSNs) have been in application since 1950s but than they were used for military and surveillance, today we are surrounded by WSNs in form of devices coming together and performing various tasks at once. These devices integrate to form a network having a base station and with the help of wireless communication it transfers data from a remote location to user end. While exploring the macro working of a WSN one discovers that these devices are sensor nodes, transducers used for sensing the environmental prospects and converting them into digital or electrical data. In a network when a large number of sensor nodes are working together then it arises the need of clustering. Various numbers of clusters are formed having a central point called as cluster head (CH). All the nodes of that cluster share their data with their respective head and than that CH is responsible for processing that data by performing tasks like compression, coding, encrypting etc. All these tasks require a certain amount of energy which should be enough to perform these tasks multiple times or for multiple numbers of rounds. Thus it becomes essential to design an algorithm that could make use of this limited energy efficiently and economically. To do so energy efficient routing algorithms came into picture.

Some pre-existing energy efficient routing protocols are LEACH, PEGASIS, TEEN and their modified versions [1]. These protocols are hierarchical in nature i.e. a colossal network is broken down into clusters or groups or regions or domains and these domains have knowledge of only nearby domains thus reducing the storage required for details of entire network [2] [3] [4]. These protocols are a good approach as they are cost effective, energy efficient and independent in real time scenario. These protocols are limited by the fact that all sensor nodes are alike in terms of their assigned task's energy consumption which means transferring data and compressing it requires same amount of energy, which is not true in real time scenario. What actually happens is that at an instant of time when number of rounds are done being executed, nodes which are doing tasks like compression, coding etc will be more drained of energy than those of performing simpler tasks like sending and receiving data. Hence it confines the lifetime and performance of network.

Subsequently, it arises the need of classifying the nodes in accordance with their working. Hence, heterogeneous nodes i.e. nodes having different energy and perform specific task [5]. Nodes are classified into normal nodes and advanced nodes, also called as cluster heads. Normal nodes for sensing and transmission of data to cluster head whereas advanced nodes for accumulation, compression, and transmission of data to base station placed far away [2]. Protocols like ECRSEP (heterogeneous stability oriented) [6], EEPCA (heterogeneous energy-efficient oriented) [7] and SEEC [8] have been implemented for an area of 100*100 sq m.

In this paper, a modified SEEC (m-SEEC) is proposed. Use of mobile nodes that act as advanced nodes to cover a wide area network of say 300 sq m. The performance of m-SEEC is than compared with pre-existing SEEC.

This paper consists of following sections. Related work, Proposed m-SEEC, Simulation work, Conclusion.

RELATED WORK

In [9] researchers have proposed LEACH, a hierarchical clustering based routing protocol. LEACH is a classical protocol and all the developments that have been done or are going to done LEACH will be the root of them. It is because of the fact that it is self-organizing and adaptive in nature. Also it features the fact that CH selection is random in nature, thus ignoring the residual energy of nodes while selecting the new head whenever a new round goes on. This approach does not unleash the overall lifetime capability of nodes hence Advanced LEACH [11] and improved LEACH [12] were introduced.

In [10] PEGASIS has been explained that works on data gathering process in sensor networks. In this sensor nodes will form a chain within the network to transmit and receive data to closest neighbour. This process gathers and fuses data at every step of transmission in the chain and then the designated node transfers the bulk of data to base station. For transferring data to base station nodes take turns so that there is reduction in average energy consumed by nodes at every round. This approach limits its working when the network is vast because to get the comprehensive awareness of network becomes difficult.

To overcome the problems of pre existing approaches, heterogeneous networks have been introduced. Existing protocols are classified as stability oriented and energy efficient oriented protocols. Stability based protocols are stable election protocol (SEP) [13], energy consumption rate based SEP (ECRSEP) [6], threshold-sensitive SEP (TSEP) [14]. Energy efficient based protocols are energy efficient prediction clustering algorithm (EEPCA) [7], deterministic energy efficient clustering (DEC) [15], distributing energy efficient clustering (DEEC) [16], threshold DEEC (TDEEC) [17], Stochastic DEEC (SDEEC) [18], LEACH heterogeneous protocol (LEACH-HPR) [19] and SEEC [8].

SEP [13] is an improvised version of LEACH, classifying nodes as normal nodes (NN) and advance nodes (AN). Selection of CH is random thus assuring the uniformity in usage of each node's energy. It also ensures extended stability of the network but lacks due to the fact that no CH could be selected if energy is low and thus no data transmission will occur.

In ECRSEP [6], according to energy consumption rate of each node its election probability of becoming CH is determined. Here the probability of becoming a CH in an upcoming round is directly proportional to the energy consumed by node in previous round.

In TSEP [14], multiple levels i.e. three of energy is defined with condition that CH selection is based on threshold level needed to be achieved to become CH. The main drawback of this is that if a single node or all the nodes die network and user will not come to know about it.

EEPCA [7] is an energy efficiency based protocol driven by the fact that nodes with higher residual energy have more probability of becoming cluster head in the upcoming round. This is done so as to increase the lifetime of network.

DEC [15] is also an energy efficient protocol where CH selection is done on the basis of residual energy but it emphasizes on the fact of reducing the uncertainties that occur during CH selection.

In DEEC [16], ratio between residual energy and average energy of network is established that determine the next CH whereas in TDEEC [17] during multilevel heterogeneous network CH selection is done by weighing over nodes with high residual energy. In SDEEC [18] two level heterogeneous network is used and approach of CH selection is same but in this non-CH nodes are put to sleep mode.

In LEACH-HPR [19] three-level heterogeneous network is formed with each node has a timer according to leftover energy. A node has more probability of being selected as CH if its leftover energy is high. Once a CH is selected than optimum path to BS is determined to transfer data. Subsequently is arises problem of delay time.

SEEC [8] establishes a middle ground in terms of both energy efficiency and stability in heterogeneous WSN. Using a 100 sq m area and with clusters which are kind of small network and self dependent of processing. This approach reduces network complexity. Also to enhance network lifetime ANs acting as CH are fixed but NNs are deployed randomly. This produces better results than EEPCA and ECRSEP in terms of throughput, stability, remaining energy and number of nodes alive at the end. This approach lags behind when applied on a broad area.

PROPOSED M-SEEC PROTOCOL

In the network a stationary base station (BS), randomly deployed normal nodes (NN), and mobile advanced nodes (AN) acting as cluster head (CH) have been used on a wide area of say 300 sq m. While transmitting over wide area more energy consumption is inevitable. More energy consumption means shorten lifetime of network.

In the given figure 1, advanced nodes (AN) are fixed i.e. the need of selecting CH at every round is eliminated. As CHs are fixed so the nodes it that particular cluster are also fixed as every node will form cluster with the nearby CH based on distance. CH are advanced nodes having energy more than that of normal nodes as they are assigned task of data collection, transmission etc.

The approach provided in [8] yields great results in terms of stability and network lifetime when applied for small area but for wide area this approach fails hence requires modifications. In above figure AN while transmitting data to base station is supposed to be nearby it in order to save energy but this increases the distance between NN and AN which results in more energy consumption by NNs while transmitting data to respective AN.

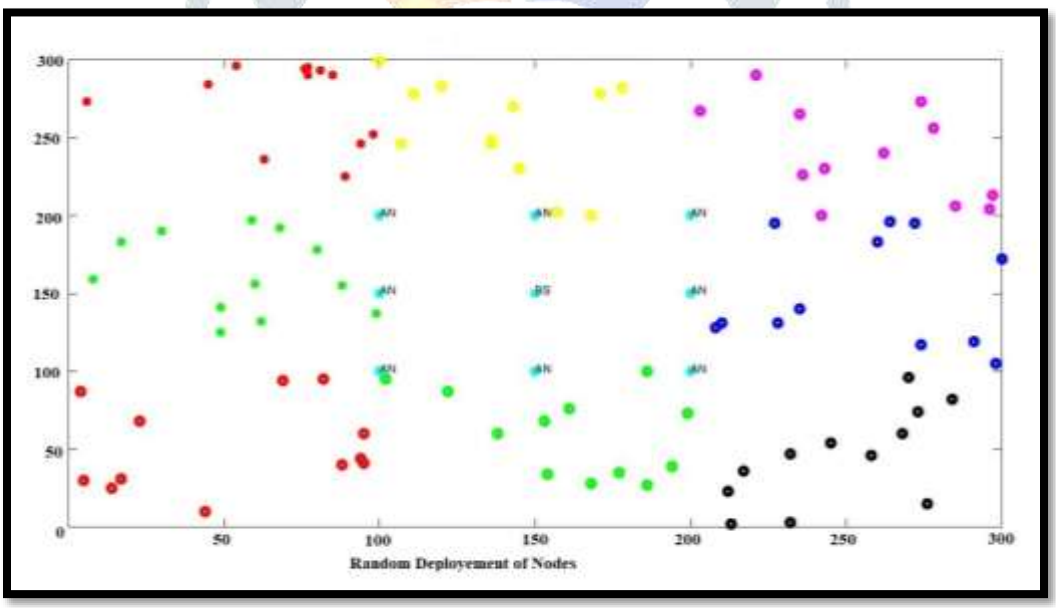

Fig. 1 Random deployment of nodes

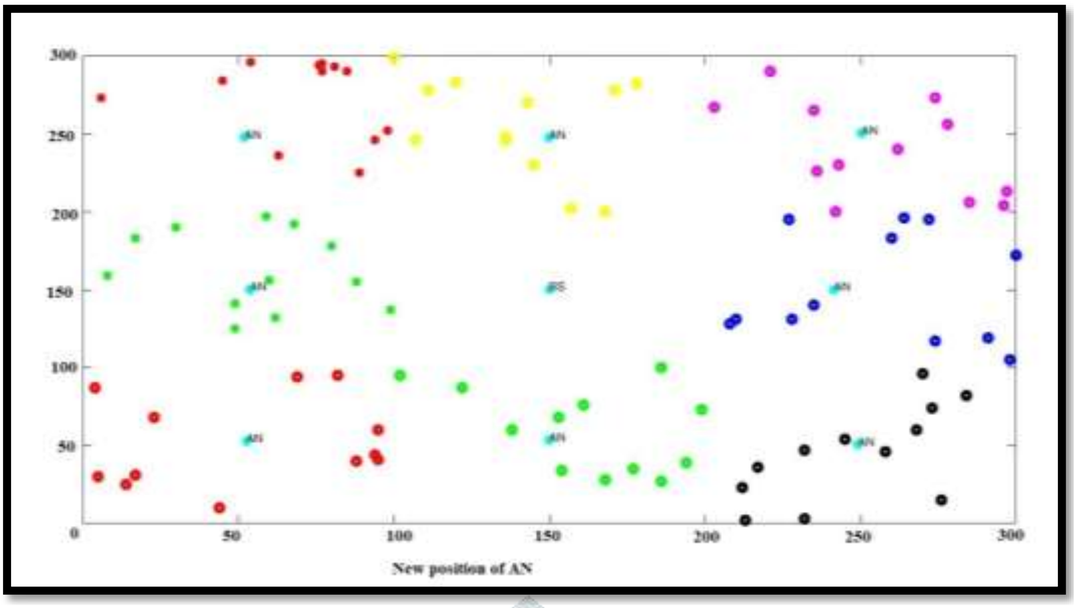

Fig. 2 ANs as cluster heads

Figure 2 is when compared with figure 1 shows that the position of ANs has been changed. Relocation of ANs is done so as to save energy on NNs while transmitting data. Here when AN is relocated inside the cluster, it is actually collecting data from NNs. As the distance between nodes and AN is reduced, NNs won't have to transfer data at large distances, energy is thus saved.

This relocation of ANs is possible because the nodes used here are mobile i.e. in real time scenario they are able to move from place to another.

As there are both stationary and mobile nodes, the network can be called as mixed-wsn [20]. Mobile nodes are merely the nodes mounted on robots capable of movement for area monitoring. Use of mobile nodes eliminates multi-hop process within clusters thus saves energy of running another algorithm inside node.

Workflow:-

Step 1> Deploy nodes:-

a) Initialize Parameters like area, number of NNs and ANs, provide energy to NNs (0.5J) and ANs (2J).

b) Deploy ANs and NNs. AN:NN::8:96.

Step 2> Join NNs to AN:-

a) Calculate distance of every NN to AN. Use D = sqrt {(X_1-X_2)^2 + (Y_1-Y_2)^2}.

(X_1,Y_1):- Co-ordinates of NN, (X_2, Y_2):- Co-ordinates of AN.

b) Calculate neighbours distance.

Step 3> Compute energy

a) Compute energy of each node while interacting to BS.

b) Compute average energy of cluster.

c) Calculate distance of each node in correspondence to the calculated average energy. This will identify the nodes that are responding to the average energy of AN.

When distance is calculated AN gets assured about relocating itself into that cluster at exact position. Hence making itself as the energy centroid of that cluster.

Also if at any instant of time any node which is using least of average energy than it goes to sleep mode.

Step 4> Data Aggregation:-

As of now, ANs have moved to new positions to collect data from NNs. But if any normal node has distance less towards BS then to that of AN than it will send data directly to BS instead of AN.

Step 5> Data transmission:-

To send data back to BS after collecting from NN, ANs move back to old co-ordinates. This saves energy of NNs for wide area data transmission.

SIMULATION RESULTS

In this section performance of M-SEEC is evaluated and compared with its parent algorithm i.e. SEEC. MATLAB is used as simulation model. Simulation parameters are as follow

Total number of sensors = 104

Number of NNs = 96

Number of ANs = 8Area = 300 sq m.

Energy dissipated per bit to run the transmitter or receiver circuit (E_{elec}) = $50*10^{-9}$ nJ/bit.

Energy dissipated during multipath (E_{mp}) = $0.0013*10^{-12}$ pJ/bit

Data aggregation cost (E_{DA}) = $5*10^{-12}$ m.

No. of alive nodes:- Fig. 3,4,5 represents the number of nodes alive with respect to number of rounds. Figure depicts the number of nodes alive after the various numbers of rounds. For example at 1000^{th} round approximately 103 (97 NNs+8 ANs) nodes are alive and at 7500^{th} round approx 3 nodes are alive according to proposed protocol.

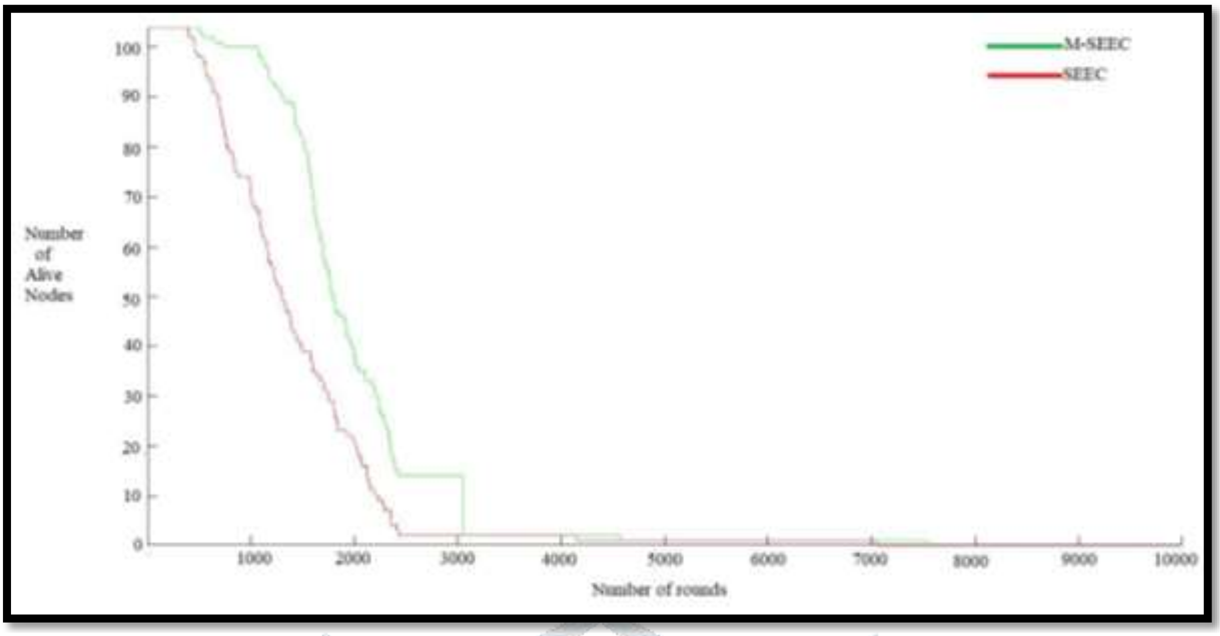

Fig. 3 Number of total alive nodes

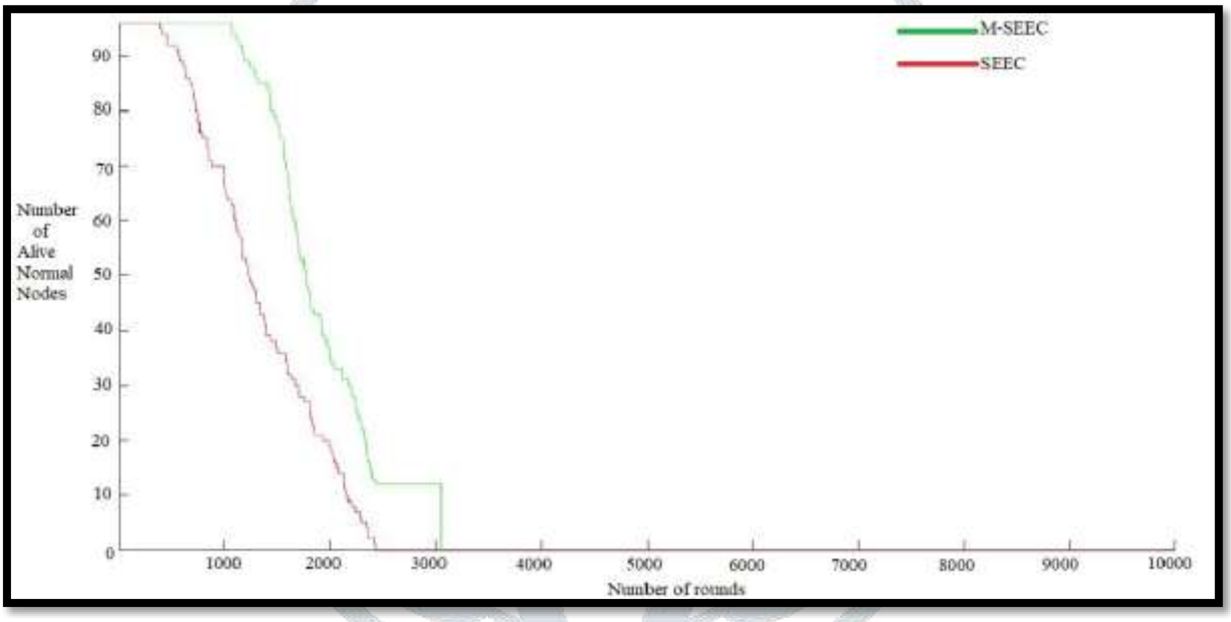

Fig. 4 Number of alive normal nodes

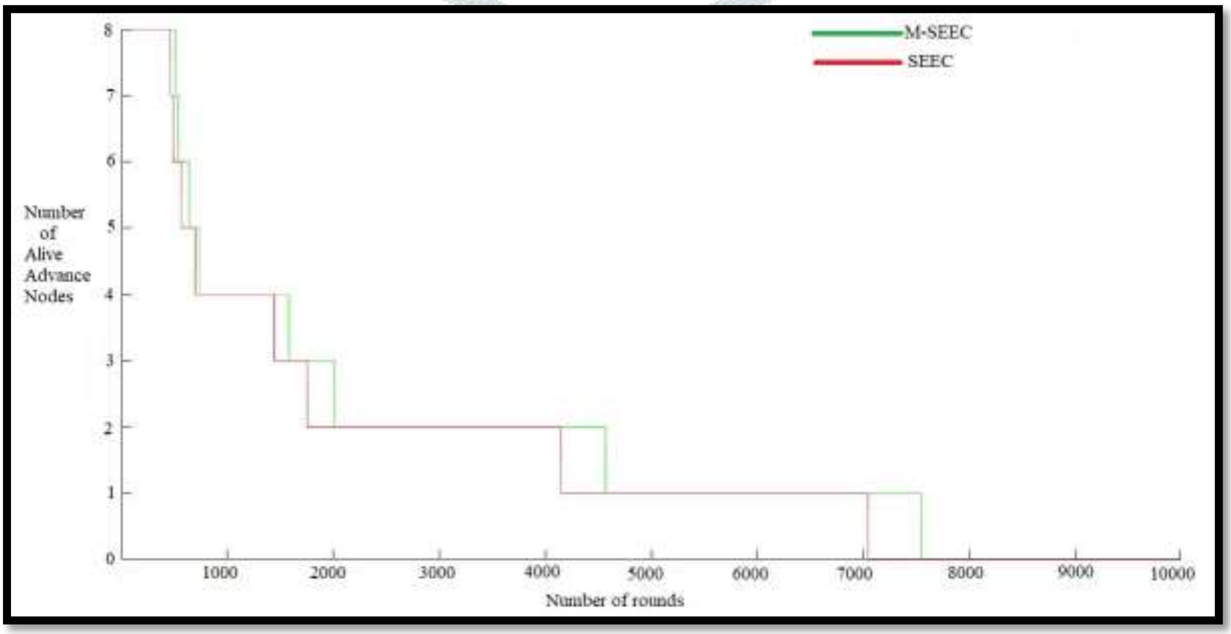

Fig. 5 Number of Alive advance nodes

No. of dead nodes:- Fig. 6,7,8 depicts the number of nodes dead at various rounds. For stability it is important that first node to be dead should have a large number of rounds executed before it is exhausted and dead. Here in M-SEEC the first node is dead at 560th round whereas in SEEC the first node is dead at 490th round. The first normal node to be dead is at 1010th round (fig.7) whereas first advance node is dead at 560th round (fig.8).

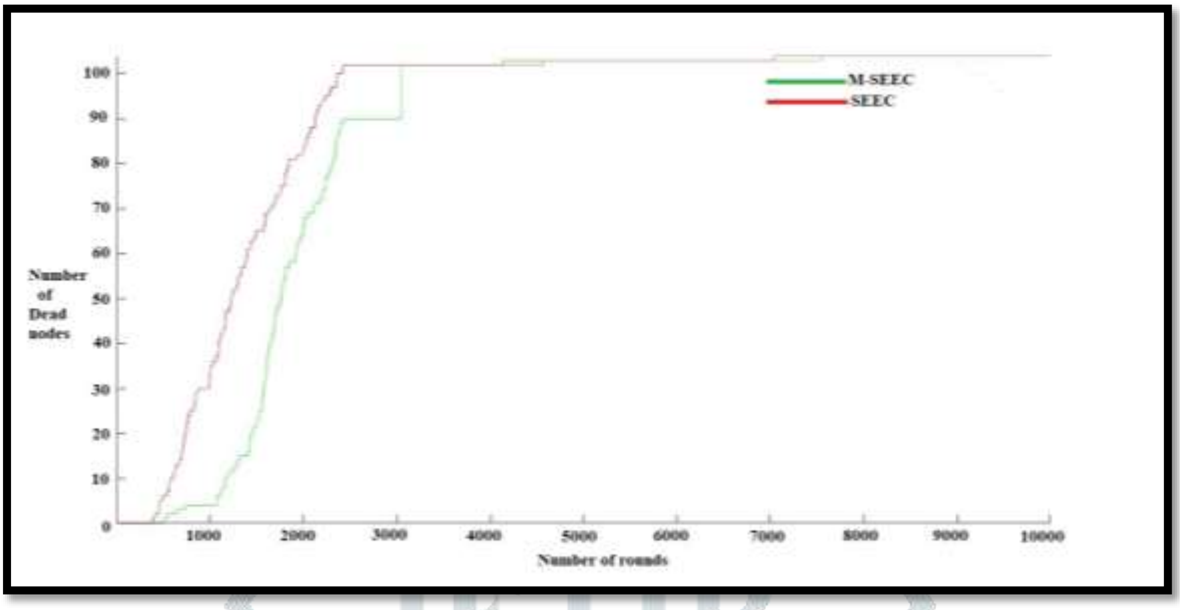

Fig. 6 Number of total dead nodes

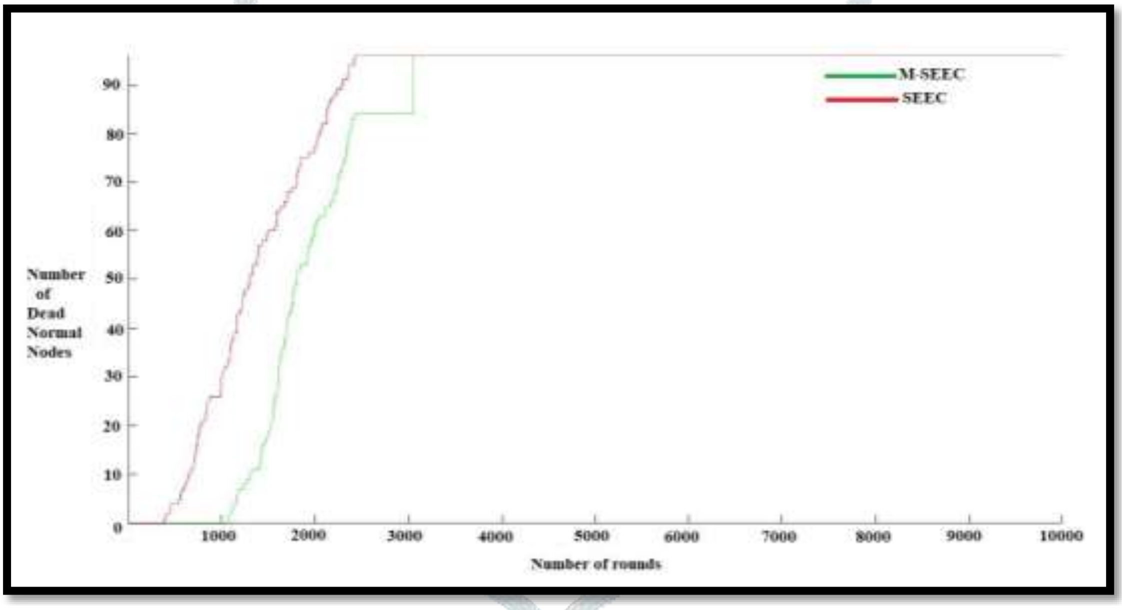

Fig. 7 Number of dead normal nodes

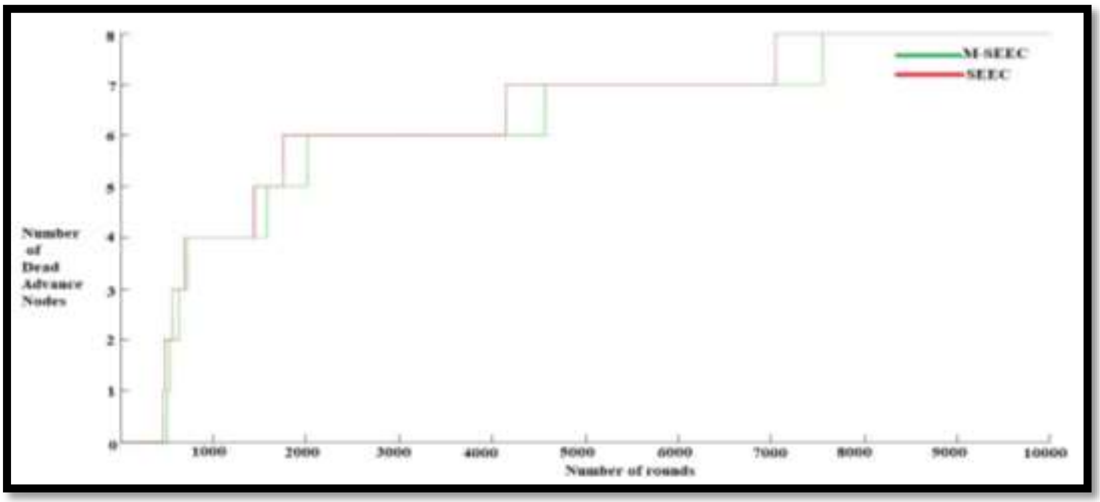

Fig. 8 Number of dead advance nodes

Throughput:- Fig. 9 represents the throughput of network which is compued as number of nodes alive with respect to number of data messages received to BS. In existing SEEC, nodes die (540th round) quickly as that of m-SEEC (720th round). Lifetime of network is inversely proportional to that of rate at which nodes die. Lesser the rate of death of nodes more will be the lifetime. Here the lifetime of network is extended by 33%

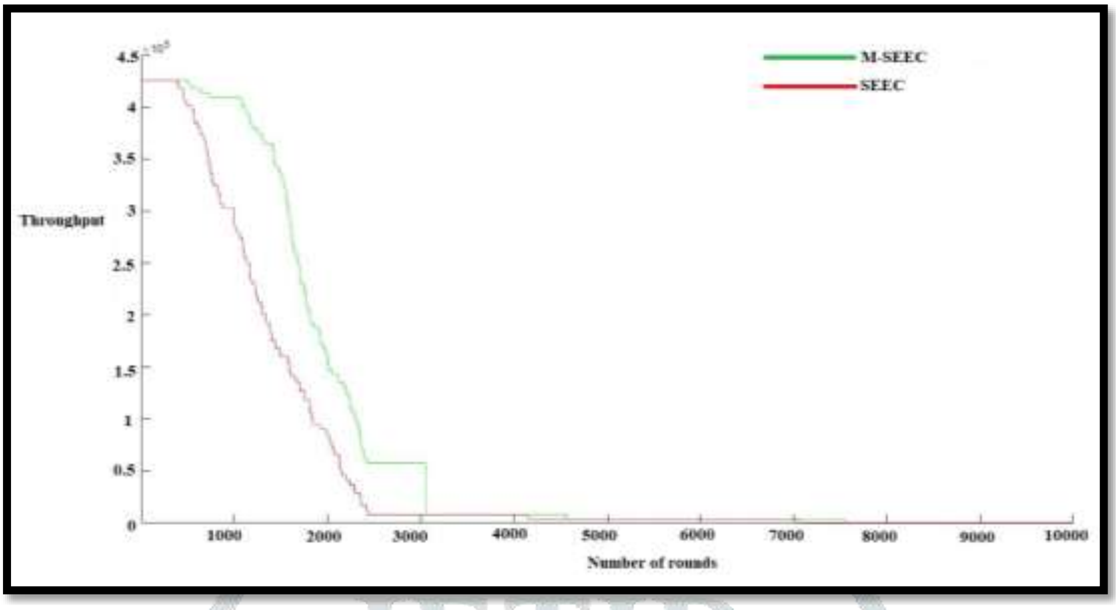

Fig. 9 Throughput of the network

Residual Energy:- Fig. 10 shows the remaining energy during every transmission round. The last round at which energy depletes in proposed protocol is 3110th. Residual energy is a measure of how long the network can survive. The larger the number of round the extended lifetime of network. M-SEEC shows the lifetime of network is more than that of SEEC by 21%.

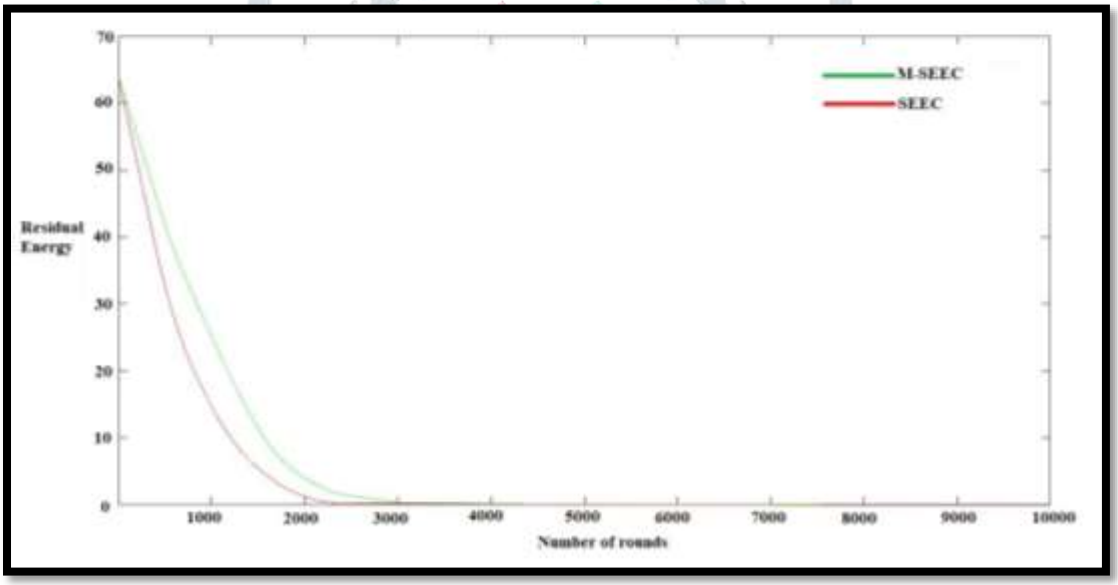

Fig. 10 Residual energy

Average Energy:- Average of total energy is shown in fig 11.This parameter is used whenever the AN is going to relocate itself inside the cluster. Average energy will deplete itself after a round is executed because data orocessing occurs. This parameter is helpful to determine the number of round that will be effciently executed before the nodes are completely exhausted.

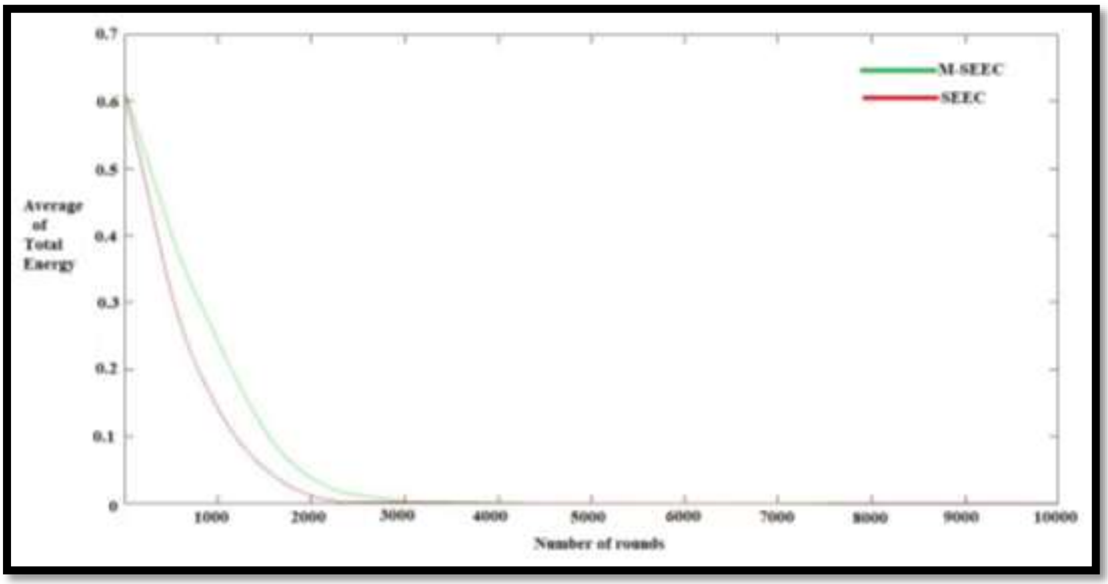

Fig. 11 Average of total energy

Rate of energy:- Here in fig 12,13 rate of depletion of energy for normal and advanced nodes is shown. For normal nodes the highest energy is 0.5J whereas for advance node he highest energy is 2J. After a round of data collecting and processing is executed energy starts to deplete like at 1000th round energy has decreased to 0.25J in M-SEEC and at 0.15J in SEEC for normal nodes. Whereas for advanced nodes at 2000th round the energy has depleted to 0.8J for M-SEEC and 0.6J for SEEC. Thus It can be concluded that depletion rate of m-SEEC is less than that of SEEC.

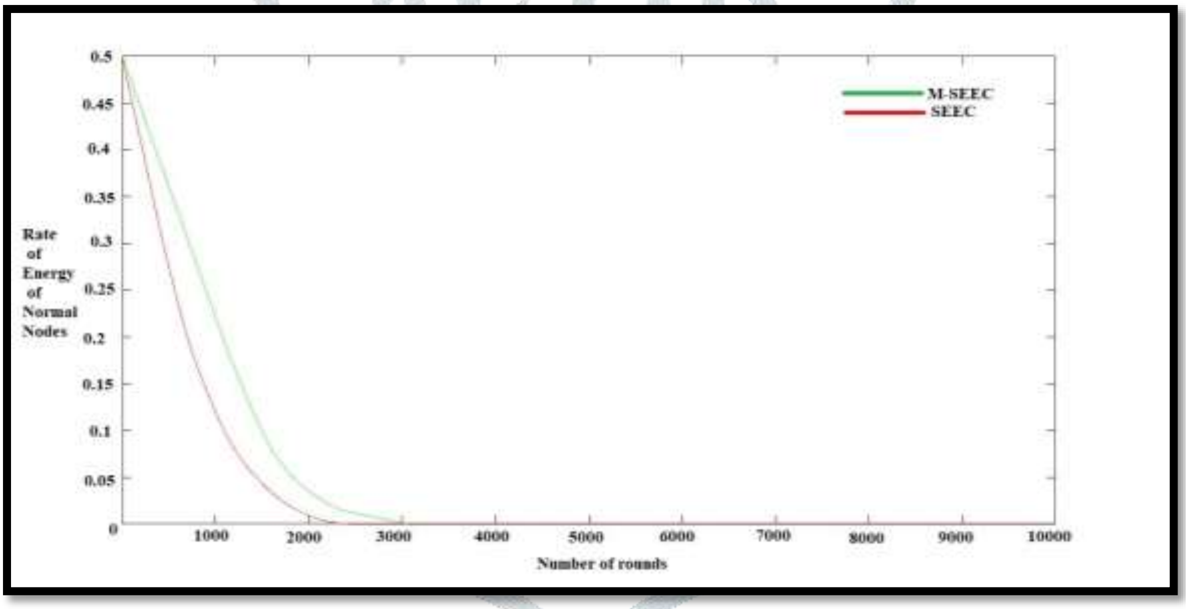

Fig. 12 Rate of energy of normal nodes.

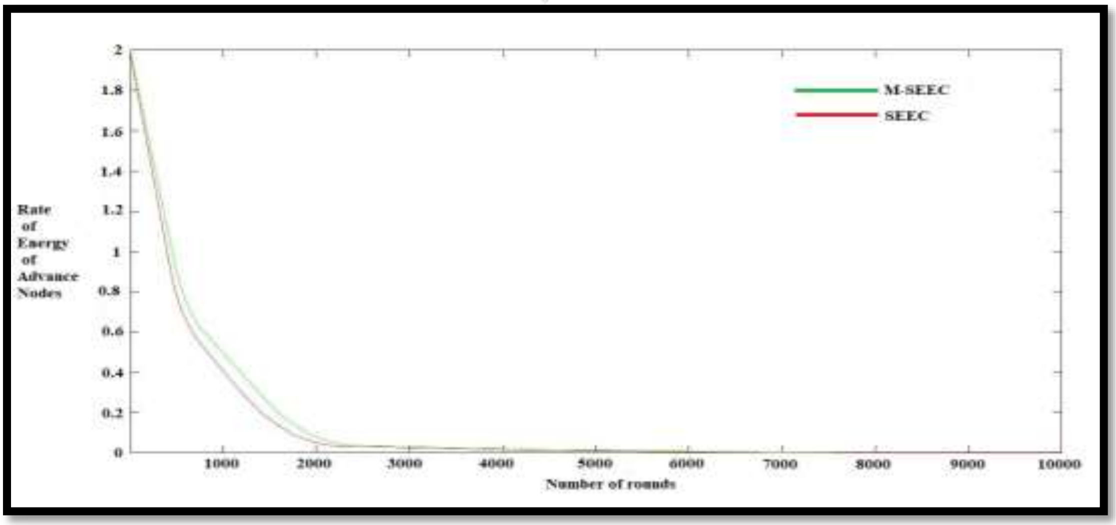

Fig. 13 Rate of energy of advance nodes.

CONCLUSION

In this paper, modified version of SEEC is proposed. The network consists of fixed clusters and each cluster is having normal nodes and movable advanced nodes. ANs are powerful in nature as they are collecting data within the cluster and transferring the data outside the cluster to base station. NNs being restricted to sensing and providing data to ANs only except when they are nearer to BS, it helps in conserving energy of both AN and NN. Mobile nodes are an emerging field of research in networking and are of great help when it comes to survillience of broad areas, they are only restricted to cost and ground non-uniformities. Clusters which were formed during first round become permanent for the whole lifetime of network thus save a great cost in terms of energy and stability.

The performance is than compared with pre-existing protocol and surpasses in terms of stability, energy efficiency in wide area cases.

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