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Mutual Exclusive Sleep Awake Distributive Clustering (MESADC): An Energy Efficient Protocol for Prolonging Lifetime of Wireless Sensor Network

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Abstract— Energy awareness is idiopathic task in wireless sensor network. For prolonging lifetime of wireless sensor network, the use of sensors plays a prerequisite role. Saving sensors energy is the main outfit so that network lifetime will improve. So keeping in mind the sensor remaining energy; a new clustering protocol which will work in sleep awake mode is proposed. Along with this mutual exclusion is used in sleep awake mode to fetch cluster head over communication range. In modernistic stint none of the protocol uses mutual exclusion algorithm in sleep awake mode. The proposed protocol Mutual Exclusive Sleep Awake Distributive Clustering (MESADC) chooses a cluster head in such a manner so that sensor lifetime will improve. If sensor lifetime improves then network's lifetime automatically improve. The performance of MESADC protocol is compared with HEED protocol. Experimental results were obtained with the help of MATLAB. On the groundwork of the comparison between two protocols one finds that the performance of MESADC protocol is prominent in prolonging lifetime of wireless sensor network as compared with HEED protocol.

Keywords: Sleep Awake, Distributive, Clustering, Sensor, Network

I. Introduction

Wireless sensor network is all about Bitsy and slashed devices. These bitsy and slashed devices are nothing but the sensor nodes. Sensing, representation of sensed information and transmission [1][20] are the three main task domain of sensor. There are two categories of wireless sensor network as shown in Figure1.

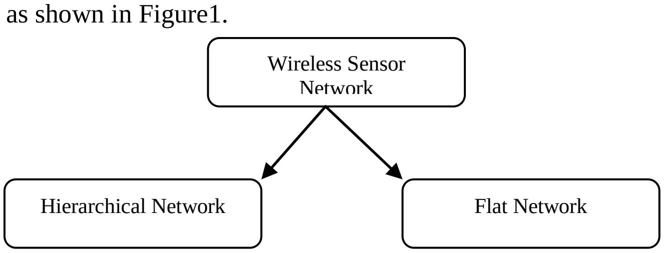

Figure 1. Categories of Wireless Sensor Network

In Flat Network role of each sensor is to individually transmitting information to base station as shown below:

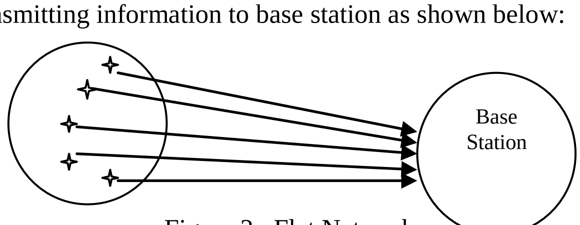

Figure 2. Flat Network

In Hierarchical Network group of sensors first transmit information to first representative and that gathered information is transmitted to base station as shown below.

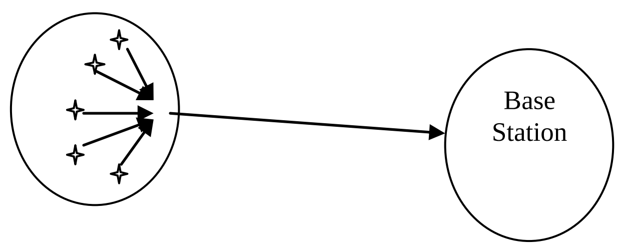

Figure 3. Hierarchical Network

From figure 2 and figure 3 it is clear that energy desolation is more in flat networks as comp aired with hierarchical networks. Clustering ensue more or less hierarchical structures. With the balm of clustering durability and scalability of network will ameliorate at large ample. It ensue data aggregation. What is happening in the clustering is that data gathered by bent of nodes has to be aggregated and send to the base station from that point. A tree like arrangement of wireless sensor nodes is used in this work. [19] All contiguous nodes are grouped to form antithetic clusters. Centralized algorithms, Distributed algorithms, Power base clustering algorithms, Multi-shot inter cluster communication, Location awareness; Multilevel clustering are the factors responsible for clustering comparison. Scheduling techniques are used for saving power of network [3]. So in WSN for increasing network lifetime we use scheduling techniques. In sleep scheduling for increasing network lifetime sensor nodes should put on hold until receiver nodes are active. This hold position is called as sleep mode. But at some instance it may leads to broadcasting delay. Whenever there is accretion in network scale, it automatically increases broadcasting delay. So for removing this broadcast delay hurdle in wsn a balance should be maintained between energy consumption and broadcasting delay [2].

As a last paragraph of the introduction should provide an overview of wsn. Rest of the paper is organized as follows, Section I contains the introduction of wireless sensor network , Section II contain the related work of sleep scheduling and clustering protocols, Section III contain the proposed work methodology of MESADC protocol, Section IV contain the experimental results of MESADC protocol, section V Concludes research work with future directions.

II. RELATED WORK

Sleep Scheduling Techniques and Clustering Protocols

This section composed of some of the existing wireless sensor network sleep scheduling techniques and clustering protocols. The various wireless sensor network sleep scheduling includes dynamic sleep scheduling, balanced energy sleep scheduling, optimal sleep scheduling, energy efficient TDMA sleep scheduling and delay efficient sleep scheduling. Likewise some of the existing clustering protocols include LEACH [4][6], LEACH-C [4], TEEN [7], PEACH [8], SHORT [9], HEED [5], EEUC [10], DHAC [11], CBDR [12], ECHERP [13]. Let us discuss all these scheduling techniques and clustering protocols.

Sleep Scheduling Techniques

Dynamic Sleep Scheduling [17][18] is used to abstain packet scheduling and if it is used with MAC layer results in high throughput. Two types of period are important in dynamic sleep scheduling one when there will be no activity and other when event occurs. While dynamic sleep scheduling it is important to control traffic and also data looses if network is large.

Balanced Energy Sleep Scheduling [14] is used for extending network lifetime by reiterating sensor nodes and using leftover sensors to sleep. It is also helpful in balancing load in sensor network which results in improvement in efficiency of sensor network. But one must take care of distance while balancing load in a network.

Optimal Sleep Scheduling [15] is used to deprecate the discontinuation in communication and helpful in prolonging network lifetime. While using this technique one must take care of connectivity.

Energy Efficient TDMA sleep scheduling [3] is used for prolonging network lifetime. With the help of this technique packet loss can be reduced at great extent. Time slots must be taken into consideration while using this sleep scheduling so that delay can be minimizes and channel utilization will improve.

Delay Efficient Sleep Scheduling [16][3] is used for abstaining collision and to reduce energy consumption to great extent. This technique is also helpful in reducing communication delays. Although it faces some difficulty during broadcasting the message. Maintaining latency pattern is challenging issue in this technique.

Clustering Protocols

Figure 4 shows the liferoad of clustering protocols. It shows antithetic categories of clustering protocols, along with this which protocols comes under particular category is also shown.

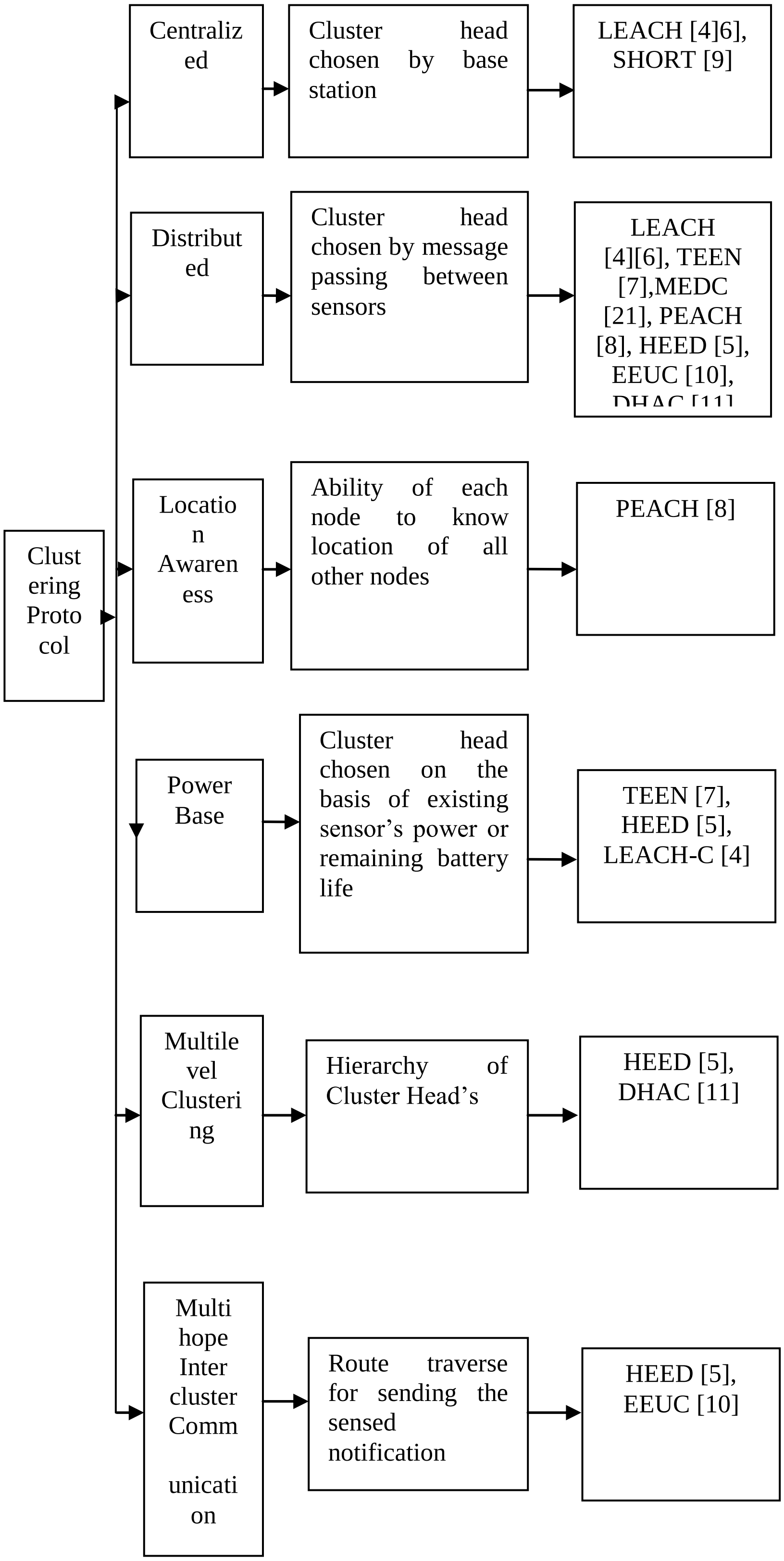

Figure 4. Life Road of Clustering Protocols

III. METHODOLOGY

The proposed protocol is MESADC (Mutual Exclusive Sleep Awake Distributed Clustering). This protocol works in homogeneous environment. By homogeneous we mean that initially all the deployed sensors have same battery life. Formation of good quality cluster head which helps in prolonging lifetime of wireless sensor network is the main goal of MESADC protocol. In this protocol cluster head's are chosen on the basis of Sleep-Awake mode in mutual exclusive way under communication range. Figure 5 is the life road of how MESADC protocol works

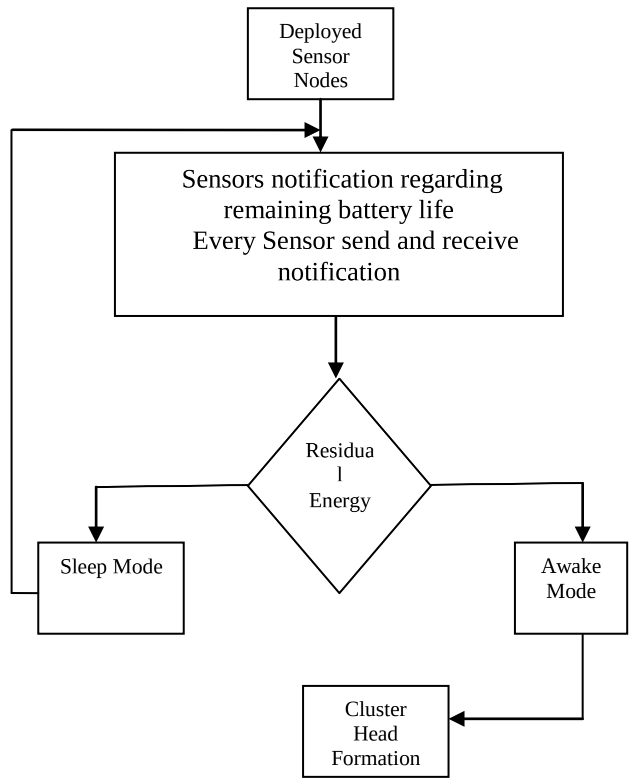

Figure 5. Life road of MESADC

In the model above the role played by following actors are very important

A) **Deployed sensor nodes:** A sensor network is composed of hundred or thousands of deployed sensor nodes. All nodes in sensor network have transmission energy upto Rf. All nodes are capable of communicating over symmetric link. All the sensor nodes have sensing unit, processor, non rechargeable battery life and last but not the least is all of them have limited memory. Sensor succession plays important role. Each sensor maintains a succession of incoming notifications.

B) **Communication Energy:** Communication energy plays a vital role in our proposed protocol. Energy / bit is used for communication. Transmission energy, electronics energy, transmission amplification energy, receiving energy, receiving energy dissipation, transmission energy dissipation must be taken into consideration. Table given below shows usage of communication energy

Parameters	Symbols
Transmission energy	$E_{tx}()$
Electronics energy	$E_{elect}()$
Transmission amplification energy	$E_{tx\_amp}()$
Amplification energy for free space	E_{fs}
Amplification energy for multipath	E_{mp}
Receiving Energy	$E_{rx}()$

Table1. Parameters of Communication Energy

If k bits are there having distance d then

Transmission energy= $E_{tx}(k)$

Transmission amplification energy = E_{tx_amp}

Transmission energy dissipation :

$$E_{tx}(k) = k * E_{elect} + E_{tx\_amp}\ (k, d)$$

$$E_{tx\_amp}\ (k, d) = k * d2 * E_{mp}$$

$$E_{tx\_amp}\ (k, d) = k * d4 * E_{fs}$$

Receiving Energy dissipation:

$$E_{rx}\ (k) = k * E_{elect}$$

C) **Sleep Awake Mutual Exclusive Mode:** Proposed algorithm totally dependent on sleep awake mode. Awake mode is one which is active in nature and Sleep mode is inactive in nature. Sensor nodes that are coming under the category of Awake mode are use for formation of cluster head. In sleep awake mode under range of communication sensors notifies the remaining battery life to each other. Initially all deployed sensors have same battery life, while notifying each other there will be some loss of energy and that energy information will be received by each node. Now every node have information regarding remaining battery life of all other sensors under communication range and all this work will be carried out in mutual exclusive way. At this stage every sensor node have succession of remaining battery life of sensors. Apply sleep awake criteria at this stage. All those nodes who are not become cluster head come into this category of sleep mode. And nodes coming under category of awake mode are used for cluster head formation.

D) **Criteria for Sensor division in Sleep Awake Mode:** Now in awake mode a given below criteria is followed. On the basis of this criteria nodes are divided into sleep and awake mode.

If coeval endurance of any node > All tarrying nodes endurance at that succession -------- (1)

Then that sensor node comes under the category of Awake mode and All remaining in Sleep mode. Sensor coming under Awake mode is using for Cluster head formation.

For following above criteria following precautions must be taken

- ✓ Equation (1) is applied for every node because at every node under range of communication have succession of remaining sensor battery life.
- ✓ If awake mode consists of more than one cluster head declaration than that issue will be resolved with the help of unique no. Every deployed node has unique number. And also there is provision of FCFS (First Come First Serve) basis.
- ✓ If there will be no cluster head declaration in Awake mode than it has to wait for next iteration.

E) MESADC Algorithm

Number of sensors = n
All sensors have unique number so
UN_i *= Unique number of node i*
T_a*= Nodes in Awake mode*
T_s*= Nodes in Sleep mode*
T_t*= Nodes in Transmitting mode*
T_r*= Nodes in Receiving mode*
E_t*= Node energy during transmission*
E_r*= Node energy during receiving*
R_f *= Frequency radius*
S_i *=* i^{th} *sensor's succession*
Layout Cluster formation (n)
    For each next track
    For each UN_i
Counter = 0
    For each UN_j *of* T_t *and* T_r *within* R_f *of* UN_i
    If $E_r <= E_t$
    Notify E_i
    For each UN_i
Put all incoming notifications from sensor j into S_i
    For each UN_i
While S_i *is not empy*
    If $E_i >= E_j$

Put nodes in T_s

Counter = 1

Else

Put nodes in T_a

For each UN_i

If Counter = 0

T_a send Cluster head declaration to UN_j under R_f

F) Flowchart of working process in Sleep Awake Mode in MESADC protocol

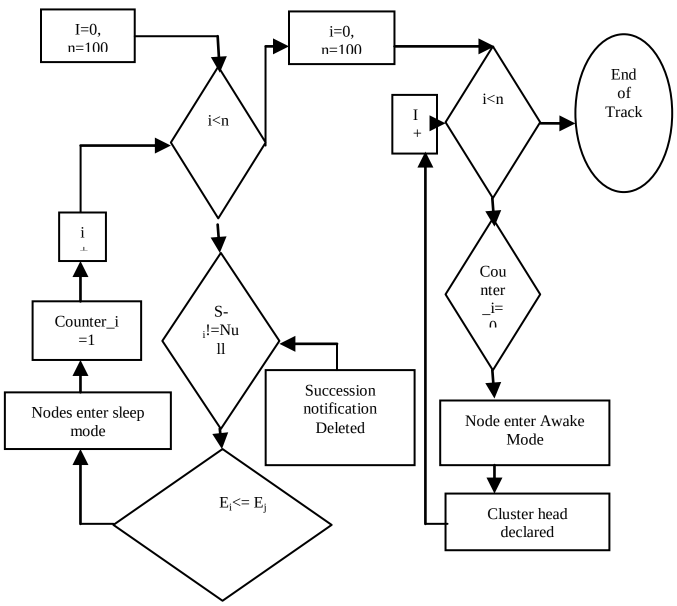

Figure 5. Flowchart of Sleep awake mode in MESADC

IV. Results and Discussion

MATLAB is use for performing our proposed protocol MESADC. The following parameters are taken into consideration:

Parameters	Symbol	Value
Number of nodes	*n*	*100, 200*
X value for plot area	X_m	*100*
Y value for plot area	Y_m	*100*
Initial energy of sensor	E_0	*0.05*
Transmission energy	E_{tx}	*50*0.000000000001*
Data aggregation energy	*EDA*	*05*0.000000000001*
Energy used for advertisement	E_{adv}	*50*0.000000000001*
Amplification energy for free space	E_{fs}	*10*0.000000000001*
Receiving Energy	E_{rx}	*50*0.000000000001*

Table 2. Parameters for performing MESADC

The results of MESADC are compared with HEED protocol, which works in distributed environment. HEED protocol is also run on same parameter along with some necessary parameters like cluster head probability, lower bound to probability and initial probability for each sensor [5]. The parameters taken for comparison are number of nodes becoming dead and the number of rounds taken. In the first case as shown in figure 6 when total number of nodes are 100, range of communication R_c = 20 and total number of rounds taken will be 1000 then total nodes dead in 700 rounds in HEED while in our proposed protocol MESADC maximum nodes dead upto last round is 80:

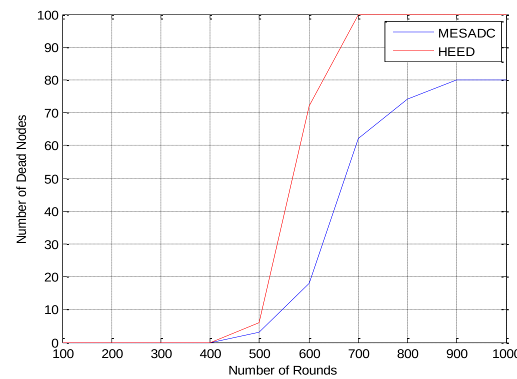

Figure 6. Comparision of MESADC Vs HEED when Rc=20 and n =100

When R_c = 40 and other parameters are same as in figure 6 then all nodes dead after 300 rounds in case of HEED while in our case maximum nodes dead are 80 upto last round as shown in figure 7.

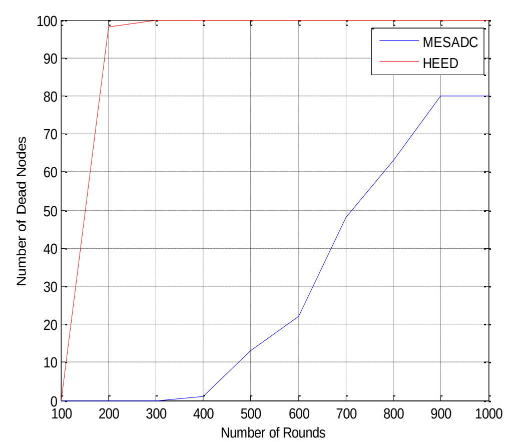

Figure 7. Comparision of MESADC Vs HEED when Rc=40 and n =100

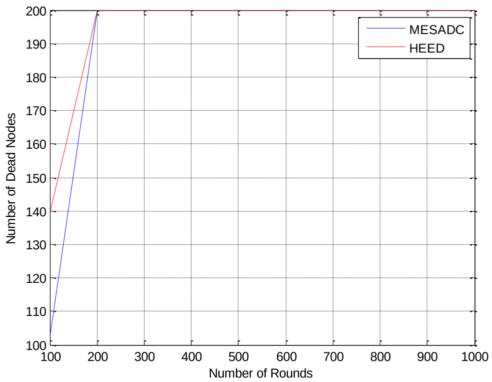

Figure 8. Comparision of MESADC Vs HEED when Rc=40 and n=200

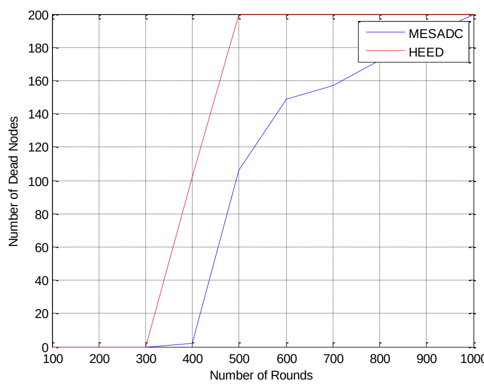

Figure 9. Comparision of MESADC Vs HEED when Rc=20 and n=200

When R_c = 40, total number of nodes are 200 then after 100 rounds, number of nodes dead in case of HEED are 140 while in our case it is 103 as shown in figure 8 and When R_c = 20, total number of nodes are 200 then all nodes dead after 500 rounds in case of HEED while in our case all nodes dead in last round as shown in figure 9. When R_c = 60, total number of nodes are 100 then after 60 rounds, number of nodes dead in case of HEED are 40 while in our case it is 15 and all nodes dead in 90 rounds while in our case all nodes become dead in 100 rounds as shown in figure 11 When R_c = 60, total number of nodes are 200 then after 40 rounds, number of nodes dead in case of HEED are 44 while in our case it is 29 as shown in figure 12. When R_c = 80, total number of nodes are 200 then after 30 rounds, number of nodes dead in case of HEED are 144 while in our case it is 123 as shown in figure 13. When R_c = 80, total number of nodes are 100 then after 40 rounds, number of nodes dead in case of HEED are 37 while in our case it is 26 as shown in figure 10. The simulation results shows how MESADC protocols helps in prolonging lifetime of wsn.

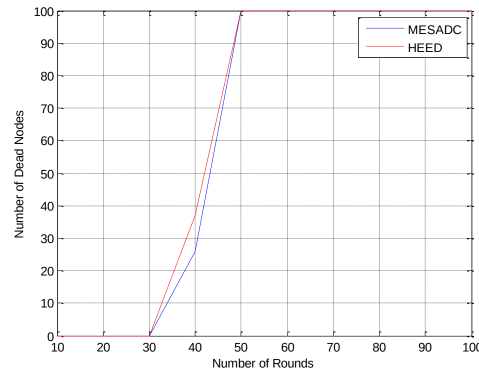

Figure 10. Comparision of MESADC Vs HEED when Rc=80 and n=100

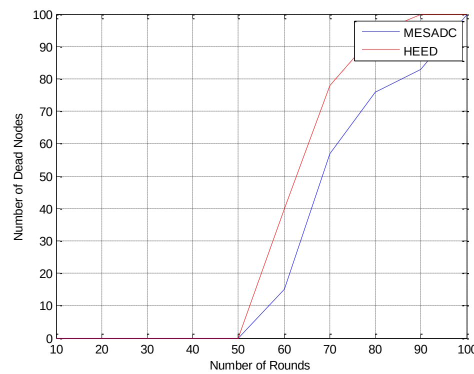

Figure 11. Comparision of MESADC Vs HEED when Rc=60 and n=100

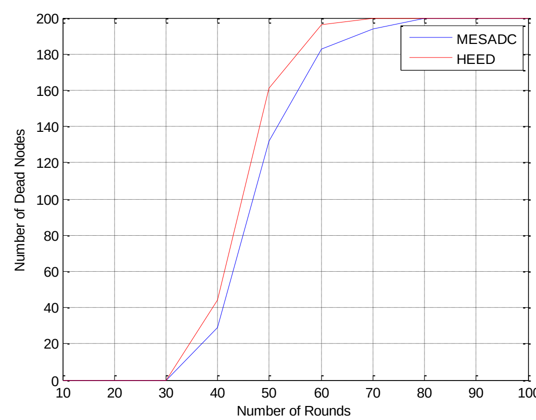

Figure 12. Comparision of MESADC Vs HEED when Rc=60 and n=200

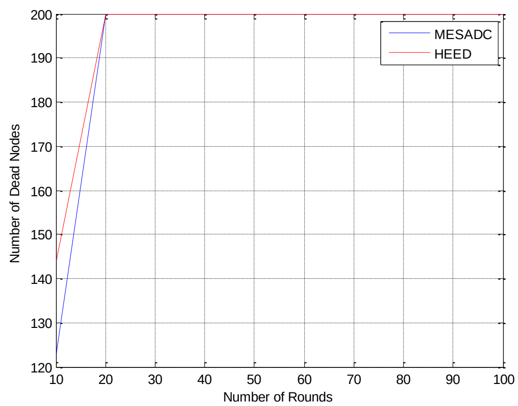

FIGURE 12. COMPARISION OF MESADC VS HEED WHEN RC=80 AND N=200

V. CONCLUSION AND FUTURE SCOPE

For any wireless sensor network sensor remaining energy plays vital role. For prolonging network lifetime sensor energy must be save. By keeping in mind the sensor remaining energy this paper presented a new clustering protocol MESADC, which is capable of saving more sensor node energy. Experimental results shows when clustering is done in mutual exclusive sleep awake way then it will be more helpful in saving sensor remaining energy. Performance evaluation is measured on the basis of number of rounds taken for nodes to become dead under antithetic range of communication. Future work can be extended by adding other parameter of interest for saving network lifetime.

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