# Comparative Analysis of HEED, MEDC, MEHEED

Urvashi Chugh, Yashwant Singh, and M.V. Ramana Murthy

***Abstract*— Clustering is heart of WSN. It plays very important role to enhance network life. This paper will firstly discuss concept of our previously proposed two new clustering protocols MEDC (Mutual Exclusive Distributed Clustering) and MEHEED (Mutual Exclusive Hybrid Energy-Efficient Distributed clustering). After that paper will present Comparative analysis of our MEDC, MEHEED with most famous existing protocol HEED (Hybrid Energy-Efficient Distributed clustering). The first proposed MEDC clustering protocol had worked on mutual exclusion selection of cluster head over range of communication. MEHEED clustering protocol is combination of two clustering protocols MEDC and HEED. MEHHED had taken mutual exclusion parameter from MEDC and residual energy parameter from HEED together. This paper will show conceptual and also experimental comparative results of these three protocols.**

**Index Terms— *Clustering Protocol, MEDC, MEHEED..***

## I. INTRODUCTION

SENSORS are manually deployed over engineered planed area for sensing certain phenomena. Sensors are assigned with three major targets. One of them is sensing; Sensing can be on regular basis or event based. Regular sensing drains more energy of sensors in contrast of event based detection. Second target for sensors is, representing this sensed information and followed by third which is transmission. Transmission is the third and most energy consuming target. The fact regarding transmission energy is that, according to communication theory, energy consumption in radio communication is proportional to the data size and square or the fourth power of the distance [13]. The fact that cannot be ignored is, In Current scenario saving energy is challenge for Sensors as they are having limited battery life. So WSN (Wireless Sensor networks) required to keep sensors alive for maximum time as much as possible. According to communication theory, energy consumption in radio communication is proportional to the data size and square or the fourth power of the distance [13].

Wireless Sensor Networks are categorized as flat networks and hierarchical networks. In flat networks, each sensor is expected to transmit the gathered information to the base station, which results in high energy consumption. In hierarchical networks each sensor will not transmit the sensed information to the base station; instead groups of sensors will transmit their information to their first representative. Clustering is more or less implementation of hierarchical network. To save communication usage in WSN concept of clustering is introduced in [12, 13]. Objective of clustering is to reduce the power requirement for communication. Clustering is a technique to group the sensors in which there will be a single cluster head and other sensors will be cluster members [1, 3]. In clusters, only cluster head will transmit aggregated information to base station instead of each sensor. Cluster members will communicate to near located cluster head only, not to the far located base station. In clustering, cluster member sensors will send their sensed information to the next level i.e. cluster head and after that, the cluster head will aggregate it and forward this information to the next level which may be the base station or head of cluster heads. The benefits of clustering are increased scalability and lifetime of the network.

In homogeneous networks for clustering cluster head rotation in is done via clustering protocols. In this paper, section II presents some related work for existing clustering protocols and their comparison followed by section III which will discuss three protocols HEED, MEDC, and MEHEED. MEDC is our proposed protocol and MEHEED is merged protocol of MEDC with existing HEED protocol. Section IV presents comparative experimental results of these three protocols, followed by the conclusion in section V.

## II. RELATED WORK

Clustering can be parameterized or compared on various factors. These factors are like; centralized clustering protocols, distributive clustering protocols; power base, location aware, multilevel and multi-hop inter-cluster communication. Centralized clustering protocols are those in which Cluster heads are chosen by base station. Base station will allocate which sensor will be the cluster head for cluster. The advantage of centralized is that there is no message passing head acknowledgement over the network. Only broadcasted message from base station will be sufficient for informing cluster head example of such algorithm is LEACH-C, SHORT etc. Distributed clustering protocols decide their cluster head via message passing in between sensors. They decide in between of them which sensor will be the cluster head and also keep Rotating their

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TABLE I. COMPARISON OF EXISTING CLUSTERING PROTOCOLS

| Factors/Protocol | Centralized | Distributive | Multi hope Inter cluster communication |
|---|---|---|---|
| LEACH[5,14] | | √ | |
| HEED[7] | | √ | √ |
| LEACH-C | √ | | |
| TEEN[9] | | √ | |
| PEACH[8] | | √ | |
| SHORT[10] | √ | | |
| EEUC[11] | | √ | √ |
| DHAC[4] | | √ | |
| **Factors/Protocol** | **Location Awareness** | **Power Base** | **Multilevel Clustering** |
| LEACH[5,14] | | | |
| HEED[7] | | √ | √ |
| LEACH-C | | √ | |
| TEEN[9] | | √ | |
| PEACH[8] | √ | | |
| SHORT[10] | | | |
| EEUC[11] | | | |
| DHAC[4] | | | √ |

Role of being cluster head, example of such algorithm is well known traditional LEACH, ERA, RRCH, and DHAC etc. Some clustering algorithm worked on the basis of network structure they use the parameter of residual energy for deciding next cluster head example of such algorithm is HEED. Some clustering protocols are differentiated on the basis of nature of sensors homogeneous or heterogeneous [2]. Above shown Table I will present comparison of different clustering protocols on different factors.

## III. CLUSTERING PROTOCOLS

This section will present firstly concept of three protocols; followed by comparisons. Three considered protocols are *HEED* (Hybrid Energy-Efficient Distributed clustering) MEDC (Mutual Exclusive Distributed Clustering) and MEHEED. Conceptual comparison has been given by Table II. Table II will discuss working parameters of these protocols in tabular manner.

### *A. HEED*

In paper [7], *HEED* (Hybrid Energy-Efficient Distributed clustering) was proposed. HEED is Distributive protocol, which selects the cluster heads among sensors on behalf of hybrid of the, node residual energy and intra-cluster communication cost [7]. HEED follow single hop communication, which means sensors will directly communicate with their respective cluster heads. The HEED algorithm is divided into three phases. First phase is Initialization phase, second is repletion phase followed by third phase that is finalizing phase [7]. The Initialization phase is for calculation of communication cost on behalf of node degree and Chprob. In the Second phase each sensor is get allocated status either of tentative cluster head of final cluster head. Tentative cluster head status will be given to sensors that are having minimum cost i.e. $S_{nbr}$. The sensor will be selected as final cluster head if it's CHprob = 1. Third phase is Finalization phase in which some sensors will be declared as cluster heads and other as cluster members. Further research work has been carried out from there iHEED [15] has been proposed. This work is implementation of HEED with data aggregation. One more protocol MCCP (minimum-cost clustering protocol) [16] also work on residual energy factor as like HEED. This protocol is for underwater sensors. ECPF (Energy-aware distributed dynamic clustering protocol) [17] also takes primary factor of residual energy. This protocol had also used fuzzy logic for cluster head selection. HEED protocol is improvised in paper PADCP (Power-Aware Dynamic Clustering Protocol for Wireless Sensor Network) [18]. HEED is limited with factor of Uniform distribution, PADCP worked with unequal distribution and shown improvement in performance.

### *B. MEDC (Mutual Exclusive Distributed Clustering) [19]*

MEDC is our proposed work in [19]. MEDC protocol works on principal of mutual exclusive selection of Cluster Heads. Cluster heads will be chosen in mutual exclusive way over range of communication. Under a range of communication sensor that's having maximum of residue energy only and only that will be cluster head. The protocol will run in iterations, each iteration follow three steps. The new cluster heads will be again chosen in succeeding iteration. When iteration starts, step 1 Sensors will advertise their remaining battery power to the sensors under range of $R_f$. All sensors will send and receive advertisement. A queue for incoming advertisements will be maintained at sensors. Step 2 will work, as now sensors will check all incoming advertisements, after that all Sensors send OK message to only those sensors that are having residue energy more than its own. This step gives clarity that if any sensor is sending OK message to the any of other sensor, which means presently there is no chance for itself becoming cluster head. If a sensor got advertisement of other sensors those are having power less than or equal to its own power then it will wait up to some period of time. This Step 2 will take TDMA slot. In step 3 each sensor will look up its own status. If sensor had not sent OK message to any other sensor that means presently itself is having higher residue battery power. So it will send a declaration message of becoming cluster head to every sensor under range $R_f$. There will be only one cluster head that's having highest residue energy no other sensor is allowed to be cluster head [19].

Algorithm

There are n sensors. Each sensor is given with ID.

Definitions

IDi: ID of node i.

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Rf: Radius of frequency.

Qi: Queue of sensor i.

Eresidual_i: Residual energy of node i.

For each Next iteration

Procedure Cluster_formation (n)

For each IDi

Counter =0

For each IDj within Rf of IDi

Advertise Eresidual_i

For each IDi

Put all incoming advertisements from sensors j

Into Qi

For each IDi

While Qi is not empty

If (Eresidual_i <= Eresidual_j)

Send ok message to IDj

Counter = 1

Else

Delete this advertisement from queue

For each IDi

If (counter =0)

Send cluster_head_declaration message to IDj

Within Rf

### C. MEHEED[20]

MEHHED is extension Work of the MEDC. The MEDC was working on the parameters of residue energy $E_{residual}$ and Range of communication. Well known HEED protocol considers three factors one of them is $Ch_{prob}$ second is $S_{nbr}$ and last is Range of communication.

TABLE I. CONCEPTUAL COMPARISION -WORKING FACTOR OF CLUSTERING

| **Working Factors for Clustering** | | |
|---|---|---|
| ***HEED*** | ***MEDC*** | ***MEHEED*** |
| $Ch_{prob}$<br>$S_{nbr}$ (cost)<br>Range of Communication | Eresidual<br>Range of Communication | Chprob<br>Eresidual<br>Range of Communication |

The proposed MEHEED will take first parameter same i.e. $Ch_{prob}$ and second parameter will be $E_{residual}$ instead of $S_{nbr}$; the third factor is same for all three protocols here i.e. Range of communication. The idea to change second parameter is, instead of considering previous calculated $S_{nbr}$, which was dependent on remaining energy of starting level, why not to consider $E_{residual}$ that have been recalculated after each iteration.

Benefit of this idea will be that recent updated value i.e. $E_{residual}$ will also reflect energy detrainment of previous cluster heads. So decisions will be more accurate. The results have been shown that this idea has given more affective results to save network life. MEHEED clustering protocol will works in two phases. First phase will be of initialization and calculations phase is same like HEED. Second phase will decide the cluster head and the members under clusters. In the starting of first phase first of all sensors under the range are queued. On basis of this queue, Communication cost and $E_{residual}$ will be calculated. After that in First phase, $Ch_{prob}$ will be calculated, with the help of $C_{prob}$. $C_{prob}$ had been be initialized with a predefined probability value [7] like of HEED. Second phase will decide which sensor will be cluster head. This decision firstly depends on $Ch_{prob}$ after that this decision will depend on the $E_{residual}$ unlike HEED, in which second factor was $S_{nbr}$.

Algorithm

Phase I

1. For each sensor i
2. Qi <-- v: v under of Rf of sensor i.
3. Compute the communication cost of i after investing on Qi also compute Eresidual.
4. Chprob i = max (Cprob × Eresidual /Emax, pmin)

Phase II

1. For each sensor i
2. If (Chprob i == 1)

cluster_head_declaration message

3. else For each sensor i
4. Advertise Eresidual_i each j within Qi
5. Queue all incoming advertisements from sensors j into adv_Qi
6. While Qi is not empty
7. If (Eresidual_i <= Eresidual_i)
8. Send ok message to sensor j
9. do Counter = 1
10. Else

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11. Delete this advertisement from queue
12. For each sensor i
13. If (counter ==0)
14. Send cluster_head_declaration message to IDj within Rf
15. Else if
16. Find j in adv_Qi having Epresent_j >= Epresent_i
17. Compare this Epresent_j with other sensors in adv_Qi and find the highest energy sensor let its r
18. do Chprob r = 1
19. Do Chprob i = max (1, Chprob i *2)

## IV. Experimental Results

The above discussed three clustering protocol HEED, MEDC and MEHEED had been implemented for experimental evaluation and comparison. Simulation has been carried out on MATLAB with parameters as energy of sensor is eo=0.05, xm=100, ym=100, eo=0.05, n=100, transmission energy is ETX= 50*1.E-12, receiving energy is ERX=50*1.E-12, free space energy is Efs=10*1.E-12, data aggregation energy is EDA=5*1.E-12, advertizing energy is Eadv =50*1.E-12, range of communication is RC=15, packet size is PS=32, and size of advertizing packet is adv =10. S(i).$ch_{prob}$ will be S(i).$ch_{prob}$=max(((S(i).$c_{prob}$*S(i).eres)/eo),S(i).pmin).

S(i).$c_{prob}$ will be initialized and S(i).eres is residual energy will be calculated after each iteration. Transmission Energy (Etx) Dissipation will be calculated via equation 1.

$$Etx(k) = k \times Eelec. + Etx\_amp(k, d). \quad (1)$$

Etx_amp (k, d) depend on path whether its free space or multipath

$$Etx\_amp(k, d) = k \times d2 \times Emp \quad (2)$$
$$Etx\_amp(k, d) = k \times d4 \times Efs \quad (3)$$

Where amplification energy for free space is represented as Ɛfs and amplification energy for multipath is Ɛmp. Receiving Energy (Erx) Dissipation will be calculated via equation 4. Receiving energy for k bits is Erx (k)

$$Erx(k) = k \times Eelec. \quad (4)$$

According to these parameters three protocols have been simulated and, network lifetime is checked. Network lifetime is experimentally checked in terms of Number of Alive nodes v/s Number of Rounds. Experimental results are shown in Fig 1 where vertical axis represents Number of Alive nodes and horizontal axis represents Number of Rounds. Results had shown that MEHHED is giving better results means number of alive nodes up to last iterations.

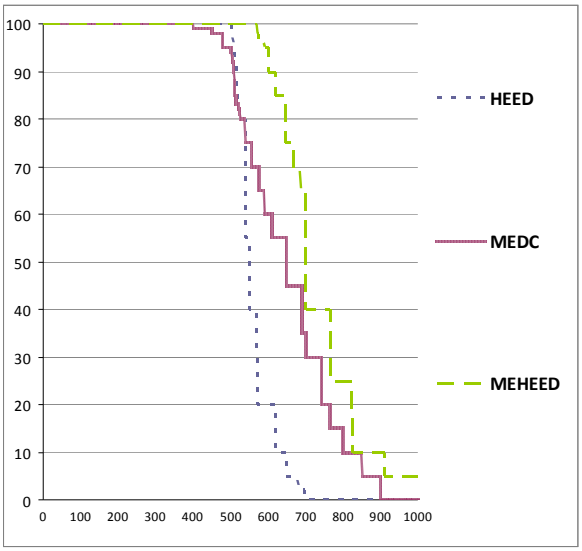


Fig 1. Comparative graph of HEED, MEDC, MEHEED

## V. Conclusion

Clustering protocols play important role for life enhancement in WSNs. This work is study of different clustering protocols and aimed at compare our new proposed protocols with HEED. This comparison is carried out in order to represent that our proposed protocols works MEHEED work even better that our previous proposed MEDC and existing HEED. Experimental results are shown to support conclusion. This work concludes that working parameter $Ch_{prob}$ and $E_{residual}$ works best together as selection criteria of cluster heads in clustering protocols.

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