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Energy Efficient Stable Clustering Using Density Variation for Wireless Mobile Sensor Network

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ABSTRACT

This paper presents density variation base clustering algorithm. The proposed scheme first defines cluster formation based on density variation using DBSCAN-DLP algorithm. This algorithm discover a cluster of same relative density nodes and automatically calculate density variation threshold parameter"α"for each cluster locally instead of using unique global density variation threshold for all clusters in the network. As a result the nodes that have relative density variation with respect to its neighboring nodes formed stable cluster and number of messages exchange during cluster formation is reduced. Secondly the cluster head (CH) selection in done on the basis of different parameters including minimum energy consumption ratio, less density variation and success factor. This lessened the usage of the energy during round time of system communication. The simulation results shows that the proposed algorithm performs better in terms of Percentage of member node has similar movement with a cluster head, cluster duration stability ratio, network lifetime, Throughput and some other parameters.

KEYWORDS*:* Wireless Mobile Sensor Network, Density, Cluster Head, Mobility, DBSCAN-DLP, Energy Efficiency.

1.INTRODUCTION

With the rapid and historic advancement in communication technologies over the last two decades, Wireless Sensor Networks are matured enough as a capable tool for monitoring the physical world. These networks consist of hundreds or even thousands of autonomous micro devices called "motes" or simply sensor nodes with some sensing, processing and communication capabilities. A typical wireless sensor network consists of a collection of static, mobile or a mixture of nodes which provide communication for one another for efficient data transmission. Wireless sensor networks whose all or some sensors have the capability of movement around the deployed area are called Mobile Wireless Sensor Networks (MWSN) [1]. Sensors are usually deployed in environments where human access is almost impossible and monitoring of specific events is difficult. Sensor networks are ideally used in commercial, civil and military applications for continuous event detection and location sensing some of them include observation, tracking, environmental and territorial monitoring, health and acoustic data collecting or monitoring of natural or man-made crises like severe weather, earthquakes, volcanic activities and battle field monitoring [2]. Wireless mobile sensor network (WMSN) is composed of a huge number of dispersed tiny mobile nodes possibly installed in remote hostile environment. Nodes are limited in terms of processing, storage space and most importantly the energy resources. The energy optimization and network management are the two major issues of mobile WSN due to the moving sensors. Mobile sensor nodes consume more energy than static nodes because of sensor mobility, hence such type of nodes face severe energy dissipations. One approached to divide the network into different cluster. Clustering is an efficient technique to extend the lifetime of network by saving energy resources [3].

Researchers have put a lot of efforts to develop best suitable energy efficient cluster protocols in WMSN in order to enhance the lifetime of the network which is the time from the deployment of sensor nodes till the death of all nodes in the network. The hierarchical [4] protocol segregates to divided network nodes into sub sections called clusters. Each cluster of the network contains the cluster head (CH) and cluster members. The cluster member nodes are responsible for gathering information from the environment and send this information to the relative CH where redundant data is fused and then passed to the base station directly or indirectly. This illustrates that the redundant data do not need to be communicated more than once to the base station and hence the energy is preserved by decreasing the number of communicating messages. A numerous of cluster based scheme has been proposed like (LEACH) [3,5,6,7,19] etc. Density-based clustering algorithms are amazing not only for finding randomly shaped clusters but also to handle the noisy node in network. In these type algorithms the dense areas of nodes are considered as clusters which are separated by low-density area.

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One of the density based clustering algorithm using DBSCAN [8] has been proposed by R.U.Anitha et. The key idea of this algorithm is that for each node of a cluster, the number of neighborhood nodes in a given radius should have at least a minimum number of neighboring nodes (α). But there are different issues in this scheme including using of global density parameter α for clustering is unsuitable for network with varied densities. Means in WMSN all nodes are mobile and the global density threshold (α) selection is not fair because of local density variation of each cluster. The second one is that in case of large network then computational cost of this scheme is too high to cluster the node.

In this paper, we have proposed a new density variation based clustering algorithms which discover a cluster of different density and automatically estimates local density variation threshold perimeter (α) for each cluster instead of using global density so that the number of messages during cluster formation is decreased. The main focus of this scheme is to identity those nodes that have relatively same density in term neighboring nodes formed a cluster. Similarly node CH selection is also done on the basis of this density variation and some other parameters.

The rest of the paper is organized as follows. The section 2 provides the literature review of some well-known clustering algorithms for mobile WSNs. Section 3 describes the some preliminary. Section 4 describe proposed scheme. Section 5 describes the cluster head selection process in the newly formed cluster. Section 6 presents energy consumption model. Section 7 describes the simulation results of our proposed scheme.

2. RELATED WORKS

This section discusses different clustering algorithms specifically designed for mobile WSN. Before going to discuss these algorithms, we need to illustrate the LEACH algorithm for static WSN, because some of the recent algorithms specially designed for mobile WSN are based on LEACH protocol. LEACH is the most popular hierarchical cluster base protocol. The operation of LEACH is comprised of different rounds where each round consists of two phases i.e. set-up phase and steady-state phase.

In set-up phase the CHs are selected probabilistically and then the member nodes join their respective CH to form the clusters. In this process each node generates a random number between 0 and 1 and then compare the threshold value with T(n) which is calculated by Equation (2.1) given below.

$$T(n) = \begin{cases} \dfrac{p}{1 - p * \left[r \bmod \left(\frac{1}{p}\right)\right]}, & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \qquad (1)$$

Where P is the percentage of cluster heads over the total number of nodes, r is the number of round and G is the number of nodes that are not selected as CH in previous 1/P rounds.

Do-Seong and Yeong-Jee Chung [9] developed the LEACH-Mobile protocol. This protocol is based on the working of basic LEACH. This algorithm ensures that each mobile sensor node is able to communicate with a specific cluster head and reorganize the cluster accordingly, but on the other hand the CH cannot be a mobile node. LEACH-Mobile does not consider the fact that how to cope with situation.

G.Santhoosh Kumar et-al presented the LEACH-ME as an enhancement of LEACH-M. To consider the fact that CH may move to another cluster at some time due to the mobile nature of the nodes, LEACH-ME propose a modification in CH selection process which consider the CH mobility as well. The main focus of this algorithm is to confirm the selection of a CH which either have no movement or minimum relative node movement. Therefore in LEACH-ME the nodes maintain some additional information for managing node mobility is role, Mobility Factors, Member List and TDMA Schedule.

Chuan Chuan and Chuan [10] presented a distributed clustering algorithm which focuses on the counting of CHs to be selected in a specific round. If the delay time passes, the node successfully acquires the channel and transmits the advertisement being a CH to other nodes. The performance of this algorithm varies for mobility model being used.

R.U.Anitha et-al [7] proposed energy efficient clustering algorithm for WMSN. In this scheme the authors introduced the sink node and gateway nodes which are static and the rest of the nodes are mobile. Cluster formation, CH selection, Inter-cluster communication and intra-cluster communication are considered in this algorithm. Mobility of the node are determined on the basis of remoteness or from the number of times a node changes its cluster as discussed in [11]. Density is computed from the ratio of the average distance from other nodes in the cluster and inter-node distance. These factors ensure the selection of such a node as CH which has average, mobility and residual energy belonging to a dense area as well.

A.Ahmad and S.Qazi proposed LEACH-MAE [12] an extension of LEACH-M by considering the residual energy of each individual sensor node in a particular round for CH selection. In LEACH-MAE the sensor nodes are mobile so they can leave their clusters at any time and join another cluster. The sensors in LEACH-MAE follow the Random Waypoint Mobility Model (RWP) [13].

Ma Changlin Ma et al [14] proposed a new clustering algorithm which is based on the residual energy difference ratio. The residual energy difference ratio is calculated using residual energy of sensor nodes and average residual energy of network, which prevent nodes with low residual energy being selected as cluster heads. Cluster-based Energy-efficient Scheme [5] (CES) is based on weighing k-density, remaining energy and mobility of node for clustering network. The periodical CH selection process after each round is carried out. In addition, CES empowers the making of adjusted 2-hop cluster whose size ranges between two limits called upper and lower edges thresholds.

An Energy Efficient Density Based Clustering for Mobile node (EEDBC-Mobile) algorithm Anitha et al [8] has been proposed. DBSCAN algorithm is utilized for cluster formation that are fundamentally more viable in finding cluster of discretionary shape. The CH selection process is as per a node residual energy, Mobility and density, for example, node closeness to its neighbors. It likewise accomplishes very uniform CH distribution over the system, but there are few problems in this algorithm. The first one is that this algorithm can't choose cluster radius (Eps) and density variation threshold (α) parameter according to distributing of nodes. It simply uses the global parameters, so that the clustering result of multi-density network is inaccurate. Mean in WMSN all nodes are mobile and global density variation threshold selection is not fair because of local density variation. The second one is that when DBSCAN is used with large network then computational cost is too high to cluster the node. Eps can be calculated by k-dist map, but drawing k-dist map spends a great deal of time.

To overcome the identified issues, we have proposed a new clustering algorithm using DBSCAN-DLP [15] to discover clusters of different densities. This algorithm automatically estimates density variation for each cluster based on their density locally which reduce the numbers of messages during cluster formation. The proposed algorithms automatically discover cluster of different density. Cluster head selection is based on density variation, energy consumption ratio and success factor of node. The major objectives of our proposed scheme are to enhance the benefits of mobility of sensor nodes, preserve the overall energy of MWSN should be better than traditional clustering schemes and also the CH selection process should increase Network lifetime and minimize the data losses.

3. PRELIMINARIES

Definiton1: (k-distance of an object p). For any positive integer k, the k-distance of object p, denoted as k-distance (p), is defined as the distance d (p,o) between p and an object o € D such that:

(1) For at least k objects o € D\ {p} it holds that d (p, o) ≤ d (p,o), and

(2) For at most k -1 objects o € D\ {p} it holds that d (p, o) < d (p,o)

Definition2: k nearest neighbor distance [15]. Given the k-distance of p, the k-distance neighborhood of p denoted by kdist (p, k) contains every object whose distance from p is not greater than the k-distance. These objects q are called the k-nearest neighbors of p.

Definition3:k density: The k density (neighborhood density) of object p denoted by Den(p,k) is define as:

$$Den(p,k) = \frac{k}{kdist(p,k)} \quad (2)$$

Where k define the number of p's neighbors.

Definition4: Density Variation. The density variation [15] of an object pi, with respect to pj, can be calculated as shown below Eq(3).

$$\text{Denvar} = \frac{(\text{kdist}(p_i, k) - kdist(p_j, k)}{kdist(p_i, k)} \quad (3)$$

The density variation defines how much denser pi than pj. Here density variation means that node mobility with respect to its neighbor nodes. Several and frequent changes in density variation are more likely due to either the node in question moving, or a large number of neighbor nodes moving at once. Less change in density variation show that node has approximately same moving speed with respect to its neighbor nodes.

Definition5: Density Variation Level (α). Density variation level (DL) [15] consist of object whose density are approximately the same. Objects pi and pj belong to the same DLC if the satisfy the following condition.

pi ,pj∈ DLn iff DenVar(pi , pj) ≤ α

Where α is density variation threshold. Each DL has its own α depend on its relative density. This is used to identify those objects whose density variations are approximately same. Every DL has calculates its own α using Equation.

$$\alpha = E(DenVarList) + SD\ (DenVarList) \qquad (4)$$

Definition 6: Estimating Density variation for cluster formation. The calculation for finding the representative number of neighbor Eps for object to form a cluster can be calculated as.

$$Epsi = maxkdist(DLi)\sqrt{\frac{Mediankisd(DLi)}{Meankdist(DLi)}} \qquad (5)$$

Due to mobility, the clustering process in the WMSN is difficult task. In this work the nodes that have relatively same density variation made a cluster. A node that density variation is greater than α does not join this cluster whose node density variation is less the α.

Definition7: Energy Consumption ratio Measurement: The energy level of a sensor node plays a vital role in the selection of CH. A sensor node with higher level of energy at any specific time can lead to greater performance in network activities. Such nodes are given higher priority to become a CH. The remaining energy (Ei) of a sensor node i is defined and ECR energy consumption ratio in current round can be calculated [11] as an Equation 6 and 6(b).

$$E_t = TE_t - (E_c + \mu) \qquad (6)$$

$$E\_c = P\_sack * E\_sack + P\_Rack * E\_Rack + P\_sd * E\_sd + P\_Rd * E\_Rd \quad (6(a))$$

$$E_{CR} = \frac{\sum_{i=1}^{n} Eci}{Ei} \qquad (6(b))$$

Where
Ei : Node i remaining energy
TE_i : Node i overall energy
E_c : Energy spent in previous transmission
Eci : Total energy consumed in one round by i-th node
μ : Energy disbursed owing to environmental causes
P_{sack} : The No of ACK sends
E_{sack} : Energy spent due to sending ACK
P_{rack} : The No of ACK received
E_{rack} : Energy consumption due to receiving ACK
P_{Sd} : The No of data packets transmitted
E_{Sd} : Energy consumed in transmitting data packets
P_{Rd}: The No of data packets received
E_{Rd}: Energy consumed in receiving data packets

Definition8: Success Factor Measurements: It can be defined as the number of successfully transferred packets without any issues [11]. This shows the reliability of a sensor that how much it is suitable to assign the responsibility of a CH. As a CH forwards not only its own data to the BS but it has the responsibility to forward all packets received from the member nodes in a specific round. For this purpose in CH selection, the success factor must be considered to preserve the energy which is being exhausted in re-transmissions of various packets in different rounds. The success factor has been calculated as given in an Eq (7)

$$Sf = \frac{(St - (Sd + Nr))}{St} \qquad (7)$$

Where Sf
St: The sum of transmitted packets
Sd: The number of dropped packets
Sr: Number of packets re-transmitted

4. PROPOSED SCHEME

The proposed scheme "density variation based clustering for MWSN " called LEACH-MDVis based on the LEACH protocol. The proposed algorithm consists of two phases i.e. Setup and steady phase. First phases defines the Setup phase by describing cluster formation based on the DBSCAN-DLP algorithm and then cluster head selection is done on the basis of different parameters including minimum energy consumption ratio, density variation and success factor. The second phase describes the communication between cluster head and non-cluster head nodes. The steady state phase does the actual data transfer between the sensing node and the base station.

The algorithm 1.1 describes the clustering process of WMSN. After deployment of nodes, every node first calculates distance metric of their first neighbors. This clustering process start with arbitrary node that has not been visited and it calculates neighbor nodes density that reachable from this node. Then every node finds out k-nearest neighbor nodes in term of density. After the calculation of density, each node should compute density variation of their neighbors. Density variation threshold can be calculated using Equation 3. This density variation threshold is used for the cluster formation of cluster. If A node whose value of density variation is less than or equal to the threshold α within the calculated radius Epsi then the cluster is formed. After this process cluster is formed using DBSCAN algorithm.

Algorithm 1.1: LEACH-MDV

```
Input: k, N
Begin
1.   N Deploy all the Node  // Random deployment of sensor nodes in the area.
2.   DistMTX = CompDisMTX(N)   //Get distance matrix
3.   Kdist  =  compKDidt(k, N)   //Get k nearest neighbor distance
4.   DenVarlist   = comptDenVar(Kdist) //Get density variation of neighbor
5.   Compute density variation threshold α using Eq3;
6.   DenVarCli = formCl(DenVarlist, α) // Form a cluster of nodes whose  density Variation is less than α.
7.   RemCl(N-DenVarCli) //Remove remaining nodes whose density variation is greater than α
8.   Epsi = EstimateEps(DenVarCli)       // Estimate Eps for each cluster
9.   For each Epsi
DBSCAN(k ,Epsi ,DenVarCli ,N)
 End of iteration
10.  Return all cluster
End
```

In the setup phase of each round the algorithm 1.1 is executed in every unvisited or newly arrival nodes.

4.1 Cluster Head Selection. This section work focuses only the CH selection phase. The cluster head selection is based on number of parameters including energy consumption ratio (ECR), density variation (DenVar) and packet drop ratio (Sf). The CH selection is based on the node weight and the weight of node is combination of ECR, density variation and packet drop ratio. The values of ECR ,DenVar, Sf can be calculated using Equation 4(b) , Equation 5 and Equation 2 respectfully. The Equation no.6 has been used for the calculation of node weight.

$$Wi=(Ei-Ecr)+(\sum_{i=0}^{1}\sum_{j=0}^{n}(pi-pj)+Sfi \qquad (8)$$

The node with highest weight is selected as a CH in cluster for specific round. Each node is identify by a state of vector including (Nid, Weight, Nstatus). Since the CH is responsible for carrying several tasks such as, coordinating the cluster members, data aggregation and transmission of this data to base station. So CH election should be periodical after each round because the CH do not rapidly exhaust their battery. At the beginning of each round, every sensor calculates its weight and broadcast a hello message to its neighboring nodes. The hello messages consist of two parts weight, node ID, weight and NodeCH, where NodeCH is set to zero. The node having greatest weight has been selected as CH for the current round. The selected CH broadcast an advertisement message (ADV_CH) including its state vector to its neighboring requesting them to join it. Each neighboring sensor node received this message and if does not belong to any cluster than compare its weight to the CH weight. If weight is less than CH weight than this node accept request as a CH.

Algorithm 1.2: Proposed CH Selection Algorithm of LEACH-MDV

```
Input: Node-ID, Weight
Begin
1.   N Deploy all the Node       // Random deployment of sensor nodes in the area.
2.   For i = 0 to N
```

```
{
If  (Ei> 0 & r mod(1/popt) ≠ 0)
{
     Compute Density           //given by (2)
     Compute Density Variation (DenVar)   // given by (3)
     Compute Ecr        //given by 5(b);
     Compute Sf         // given by  (6)
}
} End of for
3. Compute Density Variation Threshold for current round  α   //given by (4)
4. For i =0 to N
{
if ( DenVar> α)
Weight          // Compute weight given by (7)
If ( weighti> = weighti+1 )// if weight of i-th node is greater than its member nodes
 {   CHi = True   }        // Node i-th be CH
 Else
 {    CHi = FALSE;    }       //node i-th not be a CH
    }                  End of for
5. if (CH{s}=TRUE)
 {
BC (ADV) ←broadcast an advertisement message //non-CH node i join into the closest CH
}
End
```

5.

5. Energy Consumption Model. Transmission and receiving cost for a distance of d for k-bit can be calculated as follows, Transmission cost for k-bit as:

$$E_t = (Cir_{En} \times N_B) + Amp_{EN} + Dist^2 \quad (7)$$

$$R_E = (E_{cir} \times N_B)n \quad (9)$$

$$Agr_{EN} = (Cir_{En} \times N_B \times n) \quad (10)$$

Where E_t are the transmitting cost and Cir $_{En}$ is the energy consumption to run the transmitter circuit. Amp $_{EN}$ is the energy dissipation for the transmission amplifier. The cost of Data aggregation is Agr_{EN} and N_B denote the number of transmitted data bits.

6. Performance Evolution. The proposed solution has been validated through NS 2.35 simulation and comparing its performance with the rest few algorithms. The proposed scheme aims to preserve as less energy as possible and formed stable cluster. The result comparison among proposed scheme and existing schemeshas been carried using thefollowing simulation parameters shown in table 1.

Table No.1 Simulation parameters

Parameter	Value
Network size	Network size
Mobility model	Random way point
Number of sensor nodes	100
Length of Data packet	512 Bytes
Length of control packet	50Bytes
Initial Energy	1Joule
Interface Queue type	Drop tail
Communication model	Bi-directional
Mobility Model	Random Way point
Node Speed	1-30 (m/s)

Figure 1 shows the percentage of number nodes which has similar mobility with a cluster head in cluster. Moving with similar movement means that they move with the relative same speed and direction as most of member nodes including CH move. It is clear from Figure 1 that the proposed scheme increases the percentage of member nodes that have same mobility with CH. This is because of cluster is formed on the basis of nodes relative density variation with respect to its neighboring nodes and also CH is selected on the basis of relative density variation.

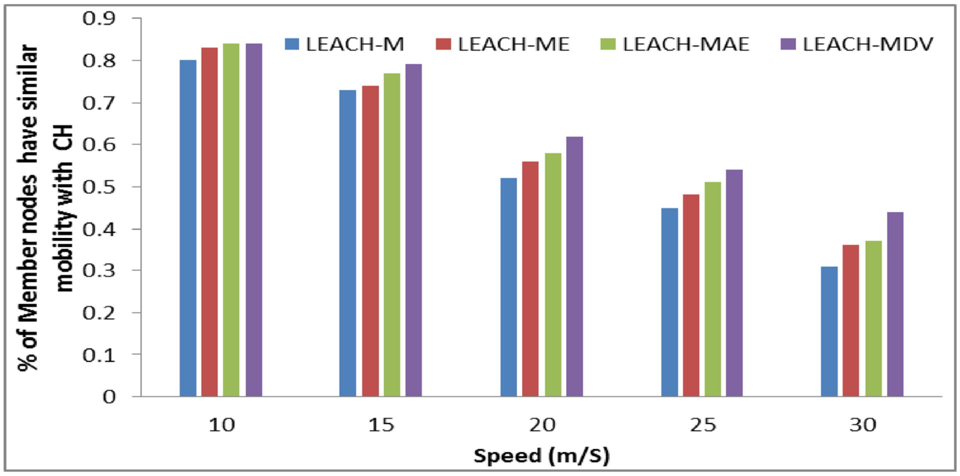


Figure No.1 Percentage of member node has similar movement with a cluster head VS Time

The average cluster duration ratiomeans the cluster stability ratio with respect to its member nodes. The higher cluster duration leads to higher stability ratio of cluster and as a result re-clusteringdoes not occurs frequently. The Figure 2 shows the average cluster stability ratio with its member nodes. It is clear from the below Figure 2 that the proposed scheme increases the cluster duration stabilityratio with respect to its member nodes speed because allthe cluster members have approximately same relative density variation. The higher density variation means that anode has frequently changed their neighboring nodes to either its own high speed or neighboring nodes having higher speed.

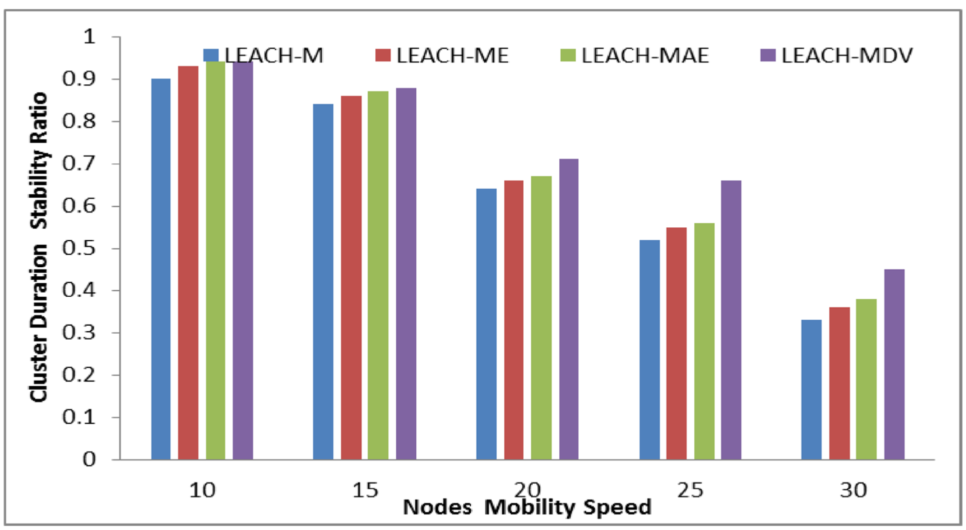


Figure No. 2 Cluster Duration Stability Ratio VS Time

The Figure 3 shows the average rate of CH change ratio in cluster with respect to its member nodes. The specific time may consist of different number of rounds or may be only one round. From the Figure 3, it is clear that in proposed algorithm CH has higher stability ratio with its member nodes as compare to the rest of schemes. This is because of suitable CH selection that has approximately same relative density variation, less energy consumption ratio and less packets drops ratio in cluster

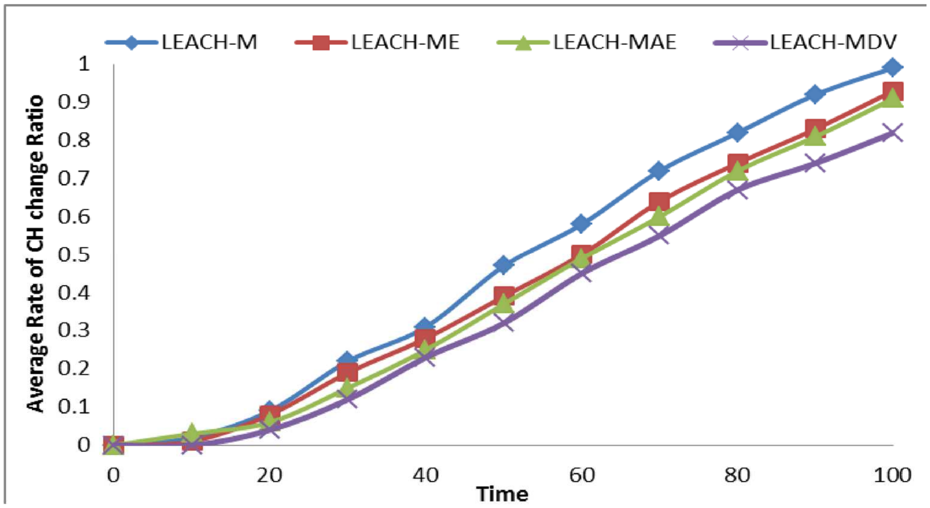


Figure No.3Average Rate of CH Change Ratio VS Time

In simulation the proposed scheme also measured the time span of the network for which it can perform the designated tasks and compare their result with the existing approach. The Figure 4 shows the comparison in term of number of alive nodes inthenetwork lifetime. The figure 4shows that lift time of network has been increased in proposed scheme because the clustering process cannotoccurfrequently due to less density variation among cluster member nodes and the selection of suitable CH.

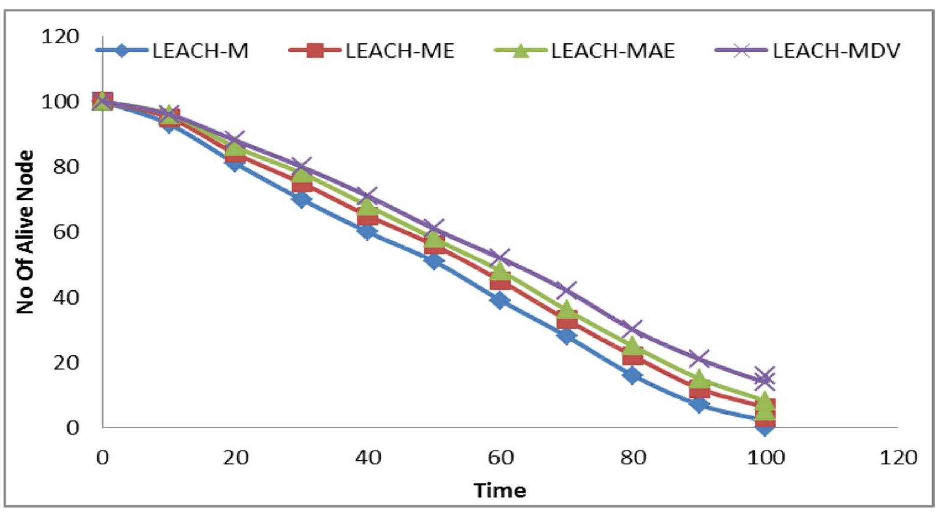
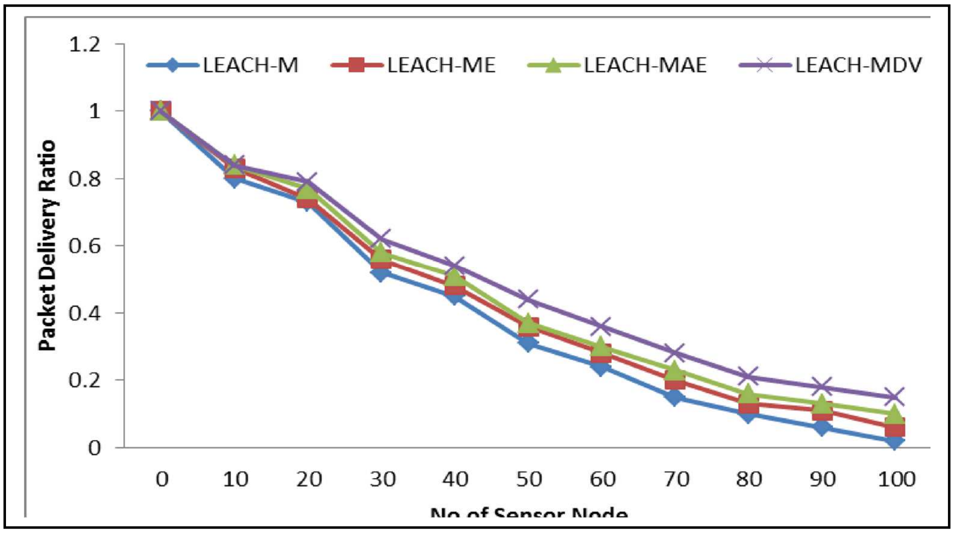


Figure No.4 Number of Alive Nodes VS Time

This represents the ratio between the numbers of sent packets of network and the number of packets that are received by the base station. The proposed scheme clustering nodes on their relative same density variation with its other cluster member. As a result clusters are stable for longer time than other schemes and cannot occurred frequent clustering process. This stability increases packet delivery ratio of network. Similarly the proposed scheme also selects stable CH and hence controlling packet drop. As a result the dropping ratio of the proposed scheme increases and the Figure 5 shows the comparison between the proposed scheme and the LEACH-ME, LEACH-M and LEACH-MAE in term of packet delivery ratio.



Figur No.5 Packet Delivery Ratio VS No of Node

Through put means that the total number of packets received by BS and total number of packets sends by networks. . Figure 6 shows the comparison through put obtaining using LEACH-MDV, LEACH-M, LEACH-ME and LEACH-MAE. This shows that the proposed scheme obtain better throughout as compare to rest schemes because of higher stability.

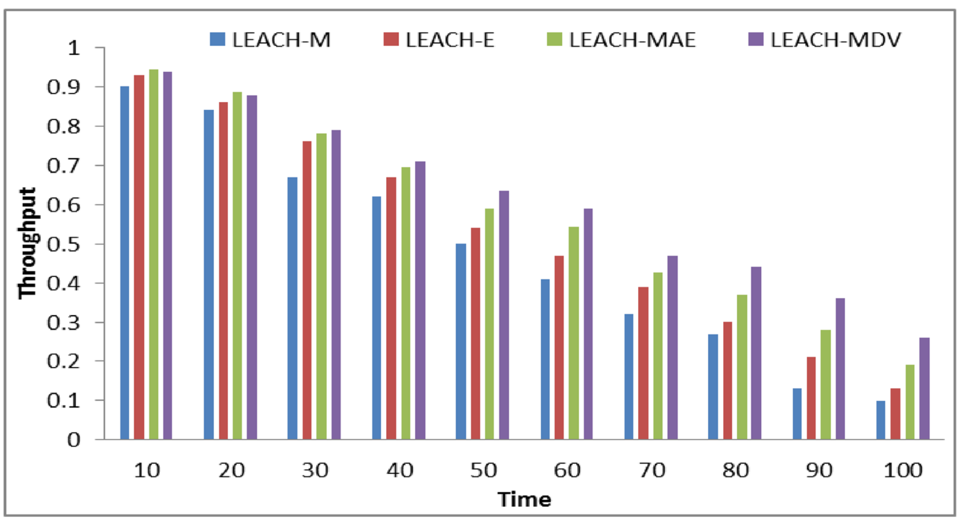


Figure No.6 Through put VS Number of Nodes

7.Conclusion. This paper has presented density variation base clustering algorithm based on LEACH protocol. The proposed schemedefined cluster formation based on density variation using DBSCAN-DLP algorithm. The proposed density variation based clustering algorithms discover a cluster of same relative density variation and automatically estimates density threshold perimeter α for each cluster locally, so that the number of messages during cluster formation is decrease. The proposed algorithms atomically discover cluster member having same density variation and formed a stable cluster. Also the cluster head selection in the newly formed cluster is done on the basis of the different parameters i.e.minimum energy consumption ratio, less density variation and success factor. This reduced the utilization of the energy during the round time of a sensor network communication. This scheme is compared against with energy efficient protocols which show that the proposed algorithm is much better than rest of schemes in terms of different metrics like average cluster duration, Network life time, throughput, andaverage rate of cluster head changed in specific time.

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