IJCTA, 9(36), 2016, pp. 107-120

An Enhanced Military Framework for Reliable Data Transmission Using Load and Energy Aware Micro-Macro Density Clustering Approach

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Abstract : In the arm force sector, military communication is considered as the most interesting domain as it shares the information promptly among the soldiers/commanders. In earlier days, military communication has been done manually by means of the foot. Recent technological advances have made the present day military communication in a facile and automated way. In order to enable the most reliable military communication, the mobile ad-hoc network is considered as the most popular and widely used way. The number of nodes used in the mobile ad-hoc network being more, the routing and communication tasks become complex which can, however, be resolved by bringing about the suitable routing path. The grouping of the nodes that exist in the same transmission range further helps to improve the routing path. In order to effectively group the nodes that fall within the transmission range, the clustering approach is chosen as the effective solution. The traditionally employed clustering algorithm could not enable an expected and reliable communication by grouping a large number of military mobile nodes which are present in various transmission regions. In the present research work, the method called Load and Energy Aware Micro-Macro Density Clustering Approach (LEMMDC) has been proposed. The first step of the proposed algorithm is to form several micro clusters. This is followed by performing the macro clustering in which the micro-clusters are grouped while transmitting necessary data between nodes residing in several regions. Hence, in this work, density based clustering approach has been adapted for accomplishing the improved clustering with respect to local density value. The performance evaluation of this novel protocol is done by using NS2 simulation environment after which the results are then compared with the existing LEACH protocol. From the evaluation of numerical results, it can be proved that the proposed research offers better result when compared to other existing approaches.

Keywords : Military communication, larger region, micro-macro clustering, local density, energy consumption.

1. INTRODUCTION

The means of communications to convey information related to armed forces is together called as military communications or military signals. The range of military communications dates back to the pre-historic period as the earliest military communications were performed by humans manually on foot. Then, the communication has been advanced to visual and audible signals and now the present age of communications has entered into an electronic age. The examples of various aspects of military communication include Jane's Military Communications include text, audio, facsimile, tactical ground based communications, terrestrial microwave, tropospheric scatter, naval, satellite communications systems and equipment, surveillance and signal analysis, encryption and security and direction-finding and jamming.

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The present modern world demands risk minimization during wars and hence the most nations attempt to reduce the risks due to miscommunication or poor communication. This has resulted in high intensity and complexity of military communication that motivates technology advancements in terms of remote systems like satellites, aircraft both manned and unmanned and computers. The multiple applications of the computers have modernized the military communications. The purpose of military communication is not only designed for warfare but also supports the event of intelligence-gathering and communication between adversaries so as to eventually prevent the war.

The establishment of an efficient route helps for achieving highly reliable and at the same time low-cost communication of military application. A large number of ad-hoc nodes present in the military environment makes routing as the difficult process for military applications. The reason for the routing complexity is attributed to the several unpredictable ad-hoc nodes that are present outside transmission range. This complexity can be resolved by one of the best approaches called clustering by which the ad-hoc nodes falling within the transmission range are grouped. The routing performance can be improved by establishing the routing path only among the cluster of nodes. However, some features of the mobile ad-hoc nodes such as limited resource availability, lack of bandwidth and so on have led to several limitations of employing clustering in the military environment.

In the present research work, the approach called Load and Energy Aware Micro-Macro Density Clustering Approach (LEMMDC) is proposed with a focus to improve the aspects of military communication. Further, Micro-Macro clustering is also introduced in this work to offer support in case of a larger region wherein the mobile ad-hoc nodes are distributed sparsely in several regions. In order to attain improved clustering experience in terms of various key parameters such as energy, local density, transmission range, load level, the method of density based clustering has been adopted in the proposed research. The performance evaluation of this novel protocol is done using NS2 simulation environment after which the results are then compared with the existing algorithms to ensure the performance improvement. The performance evaluation of the proposed research work is done in the real-time test bed as similar to the military environment by rendering the tremendous amount of communication by means of the mobile ad-hoc nodes between different regions. The results due to performance evaluation are proving that the proposed methodology can provide the better result in terms of higher clustering accuracy and so on when compared to existing approaches.

The overall organization of the proposed research work is summarized as follows: In section 2, several research methodologies that have been reported earlier for achieving an effective clustering in the mobile ad-hoc network environment is discussed. In section 3, a detailed discussion of the proposed research methodology is given. In section 4, final result evaluation conducted in the NS2 simulation environment is given. Finally, in section 5, the conclusion remarks of the overall research work is discussed in terms of its performance improvement.

2. RELATED WORK

In this section, various research methods which have been reported so far in literature for achieving the better clustering have been discussed in detail. The merits and demerits of the earlier reported methods have also been discussed so as to improve the performance of the proposed research. The method of choosing the path for sending network traffic is termed as routing. The routing can either be performed in a flat structure or in a hierarchical structure [1]. In the case of flat structure [2, 3], all network nodes are performing the similar role thus having the similar hierarchy.

While the number of nodes in the network increases, the flat structure approach could not offer scalability in spite of its efficiency for small networks. For large networks, the network saturation would result owing to excessive flow of information produced by the flat routing structure [4, 5]. Such problems can be however solved by the hierarchical routing protocols [6] which enable the division of a network into groups called clusters in a hierarchical fashion.

There are different routing schemes used between clusters (intercluster) and within clusters (intra-cluster) which helps each node to maintain entire knowledge of local information (within its cluster) however, with only partial knowledge about rest of other clusters. Thus to handle the scalability in a network having only selected nodes for data routing, hierarchical routing becomes the necessary solution [7, 8]. As there is a continual topology change in case of hierarchical approaches, the topology management plays an important role after which the actual routing takes place in MANET. The routing efficiency in a dynamic network has been improved by adopting the cluster-based structure (hierarchical structure) in network topology [9, 10]. The cluster head having a minimum Id is chosen by which the Lowest ID Cluster algorithm (LIC) [11] has been employed. This leads to an excessive id of the neighbors of the cluster head when compared to itself. When a node is lying within the transmission range of two or more cluster heads, then the node is called as a gateway. Such gateway nodes are in general help for routing between clusters. A distinct id has been assigned to each node after which the periodical broadcasts of the list of nodes that can be heard (including itself).

The definition of clustering in terms of the collection of nodes which are just d-hops away from a cluster head has been generalized by the Max-Min d-cluster formation algorithm [12]. As the number of nodes involved is larger, it is good to have an asynchronous operation of the nodes. Moreover, the clock synchronization overhead is also avoided so as to offer additional processing savings. In spite of generalizing the cluster definition to a set of nodes which are just d-hops away from a cluster head, the number of messages passing from each node has been restricted to a multiple of d-the maximum number of hops away from the nearest cluster head.

The two clustering algorithms such as the Lowest-ID and the Highest-degree heuristics are combined in a method called K-hop connectivity ID clustering algorithm (K-CONID) [13]. For choosing cluster head, connectivity is considered as the first criterion whereas lower ID as a secondary criterion. By considering only node connectivity as a criterion, numerous ties are caused between nodes. At the same time, more clusters than required are generated while using the lower ID as the only criterion. The reduction of the number of clusters formed in the network offers the way to obtain dominating sets of smaller sizes. The cluster head forms the clusters in the K-CONID approach and hence all nodes which are kept at a distance at most k-hops from the cluster head.

An ad-hoc network can be partitioned into d-hop clusters using mobility-based d-hop clustering algorithm [14] in accordance with the mobility metric. The aim behind forming d-hop clusters is to impart flexibility to the cluster diameter. As this algorithm operates on mobility metric, the cluster diameter becomes adaptable with respect to node mobility. In this method of clustering, a node has the ability to estimate its distance from its neighbor because the algorithm holds the assumption that each node can measure its received signal strength. The strength of received signal determines the proximity between two nodes. Based on this algorithm, the following five terms such as the estimated distance between nodes, the relative mobility of nodes, the variation of estimated distance over time, the local stability and the estimated mean distance can be calculated.

The clustering hierarchy protocol suitable for MANET is given by Improved Load Balanced Connection Aware (ILBCA) for performing cluster formation in military application [15]. This protocol has employed two consecutive phases such as setup and steady-state. The setup phase helps to determine cluster heads, relay nodes, the path between member node from cluster and cluster head. The collection of network data from member nodes and transmission to cluster head is performed in steady-state phase based on the topology as determined in the similar round. In a view to balancing the load in the cluster based mobile ad-hoc networks. Improved Load Balanced Distributed Weight-based Energy-efficient Clustering (LBDWEC) hierarchy routing protocol algorithm has been proposed [16]. In this method, clustering enables hierarchical routing so as to record path between cluster-heads rather than nodes for eventually avoiding routing overheads.

3. FLEXIBLE AND RELIABLE MILITARY COMMUNICATION ENVIRONMENT

The military domain, otherwise called as armed forces which involve in authorized use of deadly force and weapons for supporting the military policies of the nation/state so as to protect the nation as well as its citizens. The military operations are also defined as defense of the state and its citizens by means of war prosecution against another state. The security is ensured by sparsely distributing the military service people in various regions for monitoring any undesirable activities occurring in the specific location. As the military service people have been distributed in different regions, communication becomes indispensable for sharing the necessary information to ensure prompt response to the required citizen who is in need. The communication environment is necessary for the military field of different regions for forwarding and sharing secure and reliable information. The Mobile Adhoc network is identified as the most suitable environment for the military services to communicate information. The mobile ad-hoc network (MANET) constitutes wirelessly connected mobile devices which offer continuously self-configuring and infrastructure-less network. The static environment cannot be provided for military applications as the military force changes its location often and hence requires network topology that can easily change its location. In the case of MANET, each device can move independently in any direction hence result in frequent changing of its links to other devices. As each device should forward traffic dissimilar to its own use and requires a router. The method of building MANET by furnishing each device for continuously maintaining the information necessary properly route traffic becomes one of the prime challenges. The networks can be operated either by themselves or by connecting to the larger Internet. Hence, the network usually contains one or even multiple transceivers between nodes for ensuring a highly dynamic and autonomous topology.

The routing operation in MANET depends on the demand routing concept which signifies that the establishment of route path is performed only when there is a necessity for packet transfer. However, routing becomes the difficult task owing to the tremendous number of sensor nodes that are present in different regions in the case of the military environment. On the other hand, on-demand route establishment can be performed only within transmission range of every node which becomes again unsuitable for military application. These issues can be overcome by introducing the clustering approach in the military based MANET environment as it follows grouping of the nodes which are present within transmission range. This grouping method helps in effective route establishment between clusters of nodes.

In this research work, Load and Energy Aware Micro-Macro Density Clustering Approach (LEMMDC) is proposed with a view to performing efficient node clustering in terms of both energy efficiency as well as reliable data communication. The traditional method of clustering approach is not considered as suitable for the military based MANET environment owing to the distribution of mobile nodes in different regions. As there is a larger number of mobile nodes, cluster creation and maintenance becomes more difficult tasks. In this proposed algorithm, the micro-macro clustering approach has been adapted for performing clustering formation and maintenance to ensure higher performance. This can be done in two phases such as:

1. Micro-clustering phase.
2. Macro clustering phase.

In the first micro-clustering phase, the formation micro clusters will be performed in terms of energy, intra-cluster similarity, data transmission range and so on. In the next macro clustering phase, selection of the required cluster from the available micro clusters will be done in terms of army force requirement for ensuring data transfer. In both micro and macro clustering phase, the density based approach performs the clustering operation. The overall flow of the proposed clustering approach is given in figure 1 as given below:

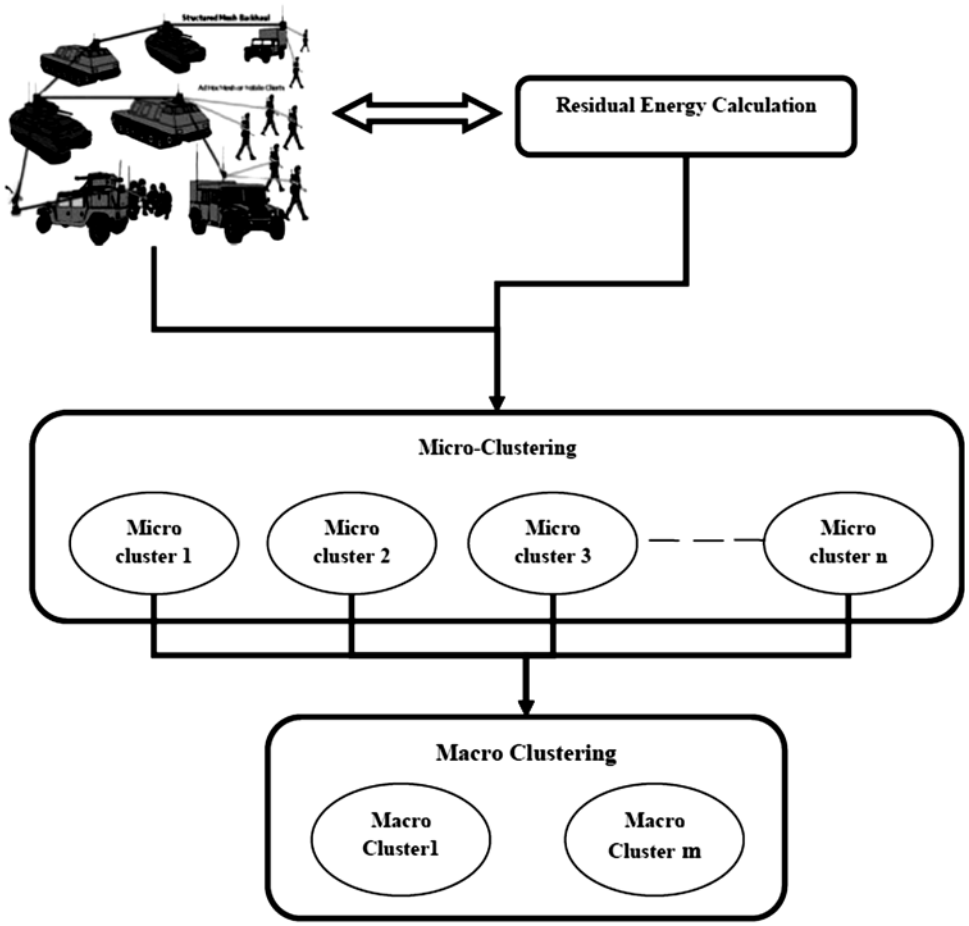

Figure 1: Overall View of Proposed Research Work

3.1. Micro-Cluster Maintenance

The micro-clustering phase is also called as ad-hoc node clustering which operates with respect to the characteristic portion of the algorithm. This phase of the clustering process is independent of any user input such as the destination or the required granularity. The purpose of this phase is to maintain statistics at a sufficiently high level of granularity by which the online components such as horizon-specific macro-clustering and evolution analysis can be used effectively. The algorithm assumes that all *q* micro-clusters are maintained at any moment. These micro clusters are denoted by $M_1 \ldots. M_q$. By associating with each micro-cluster *i.e.*, a unique id is created. If two nodes are merged, a list of id is created for identifying the constituent micro-clusters. The limitation of transmission range helps to determine the value of *q* for allowing the nodes to existing in particular transmission range into micro-clusters. This leads to increase or decrease typical values of *q* in accordance with the number of mobile nodes present in the military environment in the different region. The change in the value of *q* depends on the number of nodes present in the environment. The representation of the current snapshot of clusters by the micro-clusters for changing over the course of the mobile nodes while there is an entry of new mobile node. The status of nodes is given as energy level, load level and the storage of transmission range on table happens whenever the clock time is divisible by α^i for any integer *i*. On the other hand, the algorithm deletes any mobile nodes of order that are stored at a time in the past more remote than α^{l+r} units. At first, the initial *q* micro-clusters are created at the very beginning of the initialization process of the data communication. Then the first Init Number nodes are stored on table and density based clustering algorithm has been used in order to create the q initial micro-clusters. The selection of the larger value of Init Number enables the computational complexity of a density-based algorithm creating *q* clusters.

After establishing the initial micro-clusters, the micro-clusters are initiated for an update. Once a new mobile node X_{ik} arrives, the updating of micro-clusters is done in response to the changes. Each mobile node either requires absorption by a micro-cluster or present in a cluster of its own. The priority is given for absorption of the mobile node into a currently existing micro-cluster. Initially, the distance of each mobile node is found to the micro-cluster centroids $M_1 \ldots M_q$ in terms of parameters such as energy level, load level and transmission range of nodes. Let us denote this distance value of the mobile node X_{ik} to the centroid of the micro-cluster M_j by dist (M_j, X_{ik}). As the centroid of the micro-cluster is available in the cluster feature vector, the computation of the value becomes relatively easily. Then the closest cluster M_p is found to the mobile node X_{ik}. In many cases, it can be noted that the node X_{ik} does not naturally belong to the cluster M_p. Such cases are given as follows:

1. The mobile node X_{ik} corresponds to an outlier.
2. The mobile node X_{ik} corresponds to the beginning of a new cluster owing to the evolution of the mobile nodes.

In case if two cases mentioned above cannot be distinguished, a (new) micro-cluster of its own should be assigned by the mobile node X_{ik} with a unique id until the arrival of more mobile nodes. This decision can be made by using the cluster feature vector of M_p to assess whether the mobile node falls within the maximum boundary of the micro-cluster M_p which means within the transmission range of the mobile nodes. Then, the mobile node X_{ik} is added to the micro-cluster M_p if in case it falls within the transmission range of the mobile nodes. The maximum boundary of the micro-cluster M_p is defined as a factor of the RMS deviation of the mobile nodes in M_p from the centroid and hence M_p named as the maximal boundary factor.

It can be noted that the definition of RMS deviation is given for a cluster having more than single mobile node. For a cluster having only one previous mobile node, the maximum boundary is defined in a heuristic way. Hence, the distance which is closest to the cluster is specifically chosen. When the mobile node lies beyond the maximum boundary of the nearest micro-cluster, then a new micro-cluster must be created containing the mobile node X_{ik}. A new id is then being assigned to this newly created micro-cluster which helps in unique identification at any future stage of the mobile node routing process. However, this new micro-cluster can be created by reducing the number of other clusters by one so as to span the maximum geo-location area and to enable communication between the clusters. They can also be done by either deleting an old cluster or by joining the two other old clusters.

Initially, the proposed maintenance algorithm determines the safety aspects while deleting any of the current micro-clusters as outliers. This enables to avoid the failure in the linkage between the mobile nodes falling in different clusters. In the case of no safety ensured, the merging of two micro-clusters is initiated. The first step lies in identifying whether any of the old micro-clusters which might be the outliers can be safely deleted by the algorithm. The mere selection of the micro-cluster along with its nodes which have not been involved in transmission process for the long period of time does not hold well owing to the deletion of the micro-cluster and also leads to misleading results. In several cases, an assumed micro-cluster might correspond to a mobile node of considerable cluster available in the past history of the mobile nodes. However, it may not be available as an active cluster in the recent mobile node routing activity. From the view of the current node, such micro-cluster can be considered as an outlier.

An important goal of this approach lies on estimating the average time stamp of the last m arrivals in each micro-cluster followed by deleting the micro-cluster by means of the least recent timestamp. This above said estimation enables enhanced transmission range of a micro-cluster by a factor of m and this can be achieved by simply storing the last m mobile nodes in each micro-cluster. As the requirement reduces the storage of the number of micro-clusters by the available transmission range, the effectiveness of the algorithm is eventually reduced.

In order to identify an approximation method, the average time-stamp of the last m mobile nodes of the cluster M is found. It can be possibly achieved by means of the node about the time-stamps stored in the micro-cluster M. In addition, the time-stamp of mobile node helps in calculating the mean and standard deviation of the communication history of mobile nodes in a given micro-cluster M. Let these values be denoted by µM and M respectively. Then, the time of arrival of the $m = (2.\ n)$-*th* percentile of the nodes in M is found by assuming the normal distribution of the time-stamps. This time-stamp is used as the approximate value of the recency in terms of latest communication as it goes through the corresponding node. This value is referred as the relevance stamp of cluster M. When the least relevance stamp of any micro-cluster is below a user-defined threshold, it can be eliminated and a new micro-cluster can be created with a unique id with respect to the newly arrived mobile node X_{ik}.

In some cases, no micro-clusters can be easily eliminated. The possibility of this situation arises when all relevance stamps are sufficiently recent and above the user-defined threshold. This situation requires a merging of two of the micro-clusters occurs between the two micro-clusters that are present closer to one another within the transmission range. The new micro-cluster no longer corresponds to one id. Instead, an id list is created which is a union of the id in the individual micro-clusters. Thus, the identification of any micro-cluster arises as the result of one or more merging operations in terms of the individual micro-clusters which are merged into it. As the above updating process is executed at the arrival of each mobile nodes, execution of an additional process is performed at each clock time which is divisible by α^i for any integer i. At such time period, the details of the current set of micro-clusters are saved along with their id list and indexed by giving storage time. The least recent snapshot of order I will also be deleted if α^{i+1} snapshots of such order had already been stored on the table, and if the clock time for this snapshot is not divisible by α^{i+1}.

3.1.1. Density Based Clustering Algorithm

In this proposed research work, the density based clustering algorithm called DENCLUE is employed for clustering the number of mobile nodes present in the military environment in terms of load level, transmission range, and the energy level. The two main concepts used in this algorithm are influence and density functions. The modeling of the influence of each mobile node is performed as a mathematical function and hence the resulting function is termed as an Influence Function. As the name suggests, the influence function signifies the impact of the mobile node within its transmission range. The density function is the second factor which is given as the sum of the influence of all mobile nodes. Based on DENCLUE, definition of two types of clusters is given as center defined and multi-center defined clusters. In center defined cluster, a density attractor is considered. The influence function of a mobile nodes $y \in F$ is a function which is defined in terms of a basic influence function F, $F(x) = -F(x, y)$.

Similarly, the density function is defined as the summation of the influence functions of all mobile nodes. DENCLUE generalizes the clustering methods such as density based clustering, partition based clustering, and hierarchical clustering. In density based clustering, DBSCAN is illustrated and square wave influence function is employed for defining multicenter clusters that use two parameters such as $\sigma = \text{Eps}$, $\xi = \text{Min Pts}$. In the case of partition based clustering, *k*–means clustering is given as an example by discussing Gaussian Influence function by considering and determining the center defined clusters $\xi = 0$ and σ. In hierarchical clustering, center defined clusters hierarchy has been formed for different value of σ.

Algorithm

1. Take mobile nodes in Grid whose each side is of 2σ
2. Find highly densed cells *i.e.* nodes with more energy
3. Find out the mean of highly populated cells
4. If d (mean ($c1$), mean ($c2$)) < transmission range then two cubes are connected.
5. Now highly populated or cubes that are connected to highly populated cells will be considered in determining clusters as the similar nodes.
6. Find Density Attractors using a Hill Climbing procedure.

7. Randomly pick mobile node *r*.
8. Compute Local 4σ density, energy consumption, transmission range
9. Calculate weight value of mobile node based on parameter value
10. Pick another mobile node $(r + 1)$ close to previously computed density.
11. If den(r) < den $(r + 1)$ climb.
12. Put mobile node within (σ /2) of the path into the cluster.
13. Connect the density attractor based cluster.

In the algorithm described above, calculation of the density is based on mobility and the optimal node density is identified to provide connectivity in a network. In general, the optimal node density is identified as higher in the mobile background.

P →Probability of the connectivity.

n →the number of nodes located in the area.

μ is represented by Eq. 2

ρ →density,

π →circumference

r → radius of the transmission

$$P(k - \text{con}) \approx (1 - e^{-\mu})^n$$

$$\mu = \rho \times \pi \times r_0^2$$

$$\rho = n/A$$

Where,

n → Neighbor node count

A → Pre-defined area size, ρ = density,

π = 3.142,

r_0^2 → Transmission range radius

The calculation procedure for measuring total energy consumed E_t is for mobile node is given by,

$$E_t(s_1, d) = \begin{cases} s_i E + s_i \varepsilon_{fs} d^2, d \le d_0 \\ s_i E + s_i \varepsilon_{mp} d^2, d > d_0 \end{cases} \quad (1)$$

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \quad (2)$$

Where E represents the energy required to transmit and receive a 1-bit message.

ε_{fs} → Amplification coefficient of free-space signal a

ε_{mp} → multi-path fading signal amplification coefficient

d →distance between transmitter and receiver;

s_i →bit amount of sending information.

The value depends on the amplifier model.

With the help of the values, finally weight of each mobile node would be calculated as given by:

$$W = \alpha F(MD) + \beta F(\Delta C) + \gamma F(Y) - \phi F\left(\frac{E_t}{E_0}\right), 0 < \alpha, \beta, \gamma, \phi \le 1$$

where,

α, β, γ, γ are coefficients,

Y→ no. of times CH so far,

E_t → Residual energy,

E_0 → Initial energy,

MD → Mean distance to neighbors,

ΔC →Optimum deviation,

MD can be calculated as given below:

$$\mathrm{MD} = \frac{\sum_{i=1}^{N_s} \mathrm{DV}(i, x)}{N_s}$$

where,

X→ nodes' ID,

N_s → Number of neighbors,

DV→distance vector,

DV(i, j)→ Distance between the nodes i and j

ΔC can be calculated as:

$$\mathrm{DC} = |N_s - N_0|$$

Where,

N_s → Number of neighbors

N_0 →Optimum number of the neighbors

$$N_0 = \mathrm{floor}(N_r)$$

Where,

D→distance from Source Node (SN),

N_m→ Maximum cluster size,

Dt_1, Dt_2, and Dt_3 → threshold values of distance

C_1, C_2, and C_3 → coefficients and are less than 1(C_1, C_2, $C_3 < 1$).

3.2. Macro-Cluster Creation

The algorithm helps to generate micro-clusters for enabling it as the representation of intermediate communication. The maintenance of the communication can be done in an efficient way even for a large number of mobile nodes present in different transmission range. At the same time, the macro-clustering process stands alone from the mobile node, however, compactly interlinking of the nodes present in the micro-clusters results. Hence, establishing data communication between different regions which are not under same transmission range can also be achieved. By assuming it as input to the algorithm, the user supplies the destination location h and the number of higher level clusters k in which further routing to the different zone is desired to be performed.

It is been noted that the selection of the destination h determines the number of nodes for creating higher level clusters. The choice of the number of clusters k identifies whether the transmission can be done either in multiple different transmission regions or in more rough clusters.

At the very beginning of the routing process, the set of micro-clusters present at each stage of the algorithm depends on the entire history of mobile node communication. When a particular destination h is specified by the user above which the clusters can be found, for finding micro-clusters that are specific to that destination. In view of this purpose, the finding of the additive property of the cluster feature vector becomes very useful. This additive property is given as follows:

Property 1: Let C1 and C2 are two sets of nodes. Then the cluster feature vector CFT (C1 U C2) is given by the sum of CFT (C1) and CFT (C2).

Property 2: Let C1 and C2 be two sets of nodes such that C1 C2. Then, the cluster feature vector CFT (C1 - C2) is given by CFT (C1) -CFT (C2).

The subtractive property enables consideration of determining the micro-clusters over a pre-specified destination. This is due to the presence of two snapshots at pre-defined intervals. This leads to the determination of the approximate micro-clusters for a pre-specified destination. It is also to be noted that micro-cluster maintenance algorithm always creates a unique id while creating a new micro-cluster. While merging the two micro-clusters, an id-list consisting of a list of the entire original id's in that micro-cluster is created by the micro-clustering algorithm. Let us denote the set of micro-clusters at time *tc - h* by S (*tc– h*) and the set of micro-clusters at time tc by S (*tc*). For each micro-cluster in the current set S(*tc*), the list of ids is found in each micro-cluster. For each of the list of *id's*, the corresponding micro-clusters in S(*tc– h'*) are also found which are then subtracted the CF vectors for the corresponding micro-clusters in S(tc–h').

The creation of the micro-clusters before the user-specified destinations has ensured no domination of the results of the clustering process. Let's denote this final set of micro-clusters created from the subtraction process by N (*tc*, *h'*). The higher level clustering process then requires these micro-clusters for creating lesser micro-clusters for easy understanding and routing performance by the user. The determination of the clusters is then performed by modifying a *k*-means algorithm. In the case of using *k* means clustering enabling facile macro clustering approach, initial centroids can be randomly generated for the effective performance of macro clustering.

In this approach, the micro-clusters in N(*tc*, *h'*) are considered as pseudo-points for re-clustering in order to determine higher level clusters. The k-means algorithm randomly chooses *k* nodes as random seeds and then iteratively assigns the mobile nodes to each of these seeds for creating the new partitioning of clusters. The old set of seeds is replaced by the centroid of each partition in all iteration. There are few ways by which the k-means algorithm should be modified while considering the micro-clusters are used as pseudo-points:

At the initialization stage, seeds are no longer picked randomly, however, involved in sampling probability proportional to the number of nodes in a given micro-cluster. The corresponding seed is then referred as the centroid of that micro-cluster.

At the partitioning stage, the distance of a seed from a given pseudo-point (or micro-cluster) becomes equal to the distance of the seed from the centroid of the corresponding micro-cluster.

At the seed adjustment stage, the new seed for a given partition is defined as the weighted centroid of the micro-clusters in that partition.

It is required to understand that only two (carefully chosen) snapshots from the pyramidal destination of the micro-clustering process are essential for executing the macro-clustering process. The compact feature of the input enables the user to have considerable capabilities for enquiring the stored micro-clusters having varied levels of granularity and destinations.

4. EXPERIMENTAL RESULTS

In this section, the network simulation is employed for evaluating the performance of the proposed scheme. Hence, NS2 simulator is used for comparing the performance results with three representative cluster-based routing protocols such as LEACH-C, FCM, HSACP, improved Load Balanced Distributed Weight-based Energy-efficient Clustering (LBDWEC) hierarchy routing protocol algorithm, and Load Balanced distributed weight-based energy-efficient clustering Landmark Adhoc Routing (ILB-LANMAR) Protocol algorithm. The performance is measured in terms of the characteristic such as average energy consumption, network lifetime, the total number of messages successfully delivered, the number of live nodes and data integrity level.

The specifications in terms of setting values considered while configuring network during the experiments are provided in Table.1. These values can, however, be changed and optimized based on different applications. In the present research work, the selections of values of time intervals in Table.1 are meant to reduce the experiment time for observation.

Table 1
Setting Values for Experiments

Parameter	*Value*	*Unit*	*Description*
N	30	Nodes	Total number of nodes
C	3	Clusters	Number of clusters
$T_{recluster}$	30000	ms	Time to recluster
T_{sample}	500	ms	Sample time for sensing
T_{cycle}	5000	ms	Time interval between two data transmission
T_{DataRx}	500	ms	Time to receive data of CH
$T_{Dataagg}$	50	ms	Time to aggregate data at CH
$T_{Radioon\_CH}$	600	ms	Maximum time to keep radio on for sending
$T_{RadioonCM}$	100	ms	Maximum time to keep radio on for sending
ΔV_{th}	100	mV	Voltage threshold for dead node

The performance evaluation of the proposed method in terms of measure values is compared for implying the improvement and also depicted in the following figures 2-6.

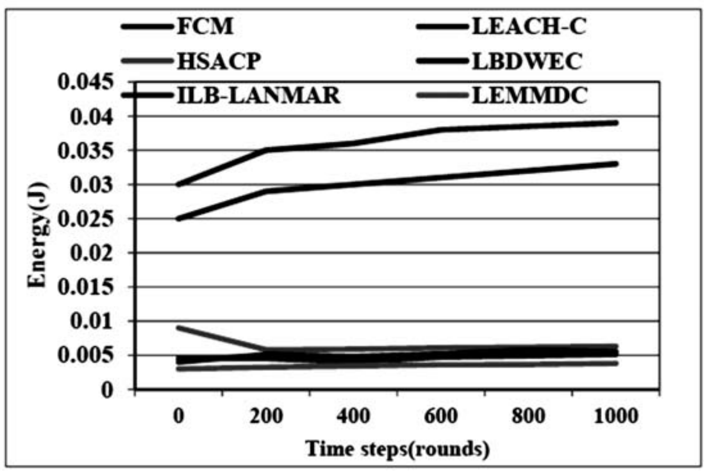

Figure 2: Energy Consumption

In the proposed LEMMDC scheme, the method of the cluster formation and routing has been employed in each cluster for reducing the energy consumption owing to unnecessary re clustering. In order to validate the effectiveness of the proposed energy efficient LEMMDC approach, the comparison of the consumed amount of energy during the setup phase with that of the existing cluster-based schemes is done as shown in Figure 2. It can be deduced that ILB-LANMAR, LBDWEC, HSA Cluster-based Protocol (HSACP), Low-Energy Adaptive Clustering Hierarchy Centralized (LEACH-C)and Fuzzy C-Means (FCM) consumes far more energy than that of the proposed scheme. The energy dissipation during the start of each round is constant with LEMMDC. This is attributed to the similar number of transmissions and receptions occurring in each round (large transmission power to reach the BS and the probability of collision is small). However, in case of ILB-LANMAR, LBDWEC, HSACP, LEACH-C and FCM, the amount of energy consumed differs between the rounds owing to its dependence on the number of cluster heads and their locations within the changing network in each round. By means of this proposed scheme, energy consumption during the setup phase occurs at only first round hence ensures minimization of energy consumption in each round.

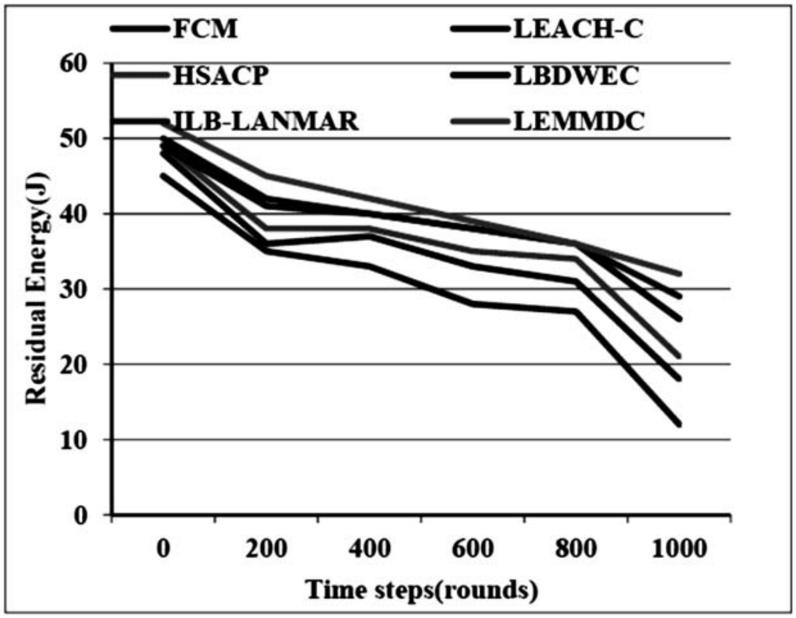

Figure 3: The Total Remaining Energy of the Network

Figure 3 depicts the total remaining energy in the network. It is observed from the figure that the energy consumed by the proposed scheme is significantly smaller than the others, particularly in the early rounds. This is due to effective cluster formation.

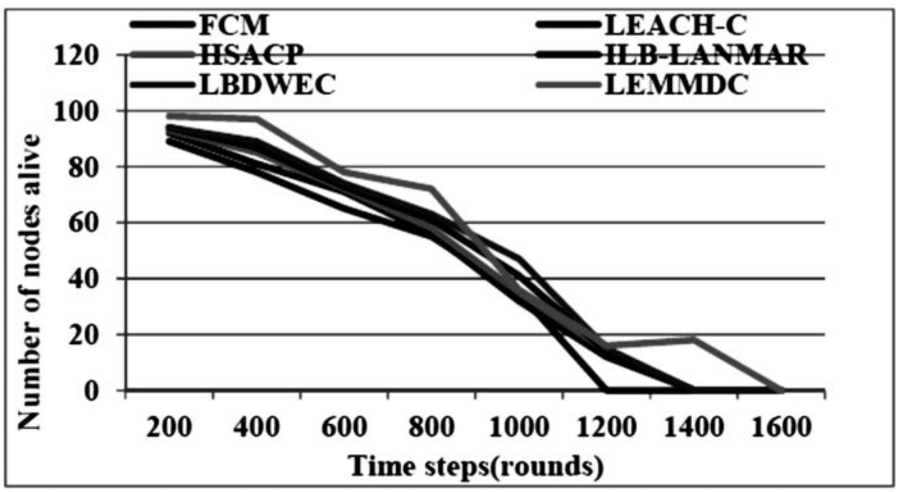

Figure 4: Comparison of the Number of live Nodes as the Round Proceeds

The above figure 4 represents the number of live sensor nodes while proceeding start of the round with 0.5 J/node. It depicts that the time required by the proposed LEMMDC scheme for the first node to expire is about 35%, 26%, and 9 % larger than that of ILB-LANMAR, LBDWEC, HSACP, LEACHC and FCM respectively. The time at which all the nodes die is also significantly larger than other existing methods. Hence, the proposed LEMMDC scheme helps for remarkable improvement in the network lifetime with respect to both the time the whole node initiates to die (t_1) and the time when nodes are dead (t_2). The relatively small interval between t_1 and t_2 implies that the proposed scheme can successfully exhibit load balancing among the nodes.

A node is meant dead while its total energy gets depleted followed by execution of dead node from the subsequent rounds. Figure 5 represents the round number during which some portion of the nodes becomes dead. The figure further illustrates that the proposed LEMMDC scheme consistently outperforms the existing schemes like ILB-LANMAR, LBDWEC, HSACP, FCM and LEACH-C.

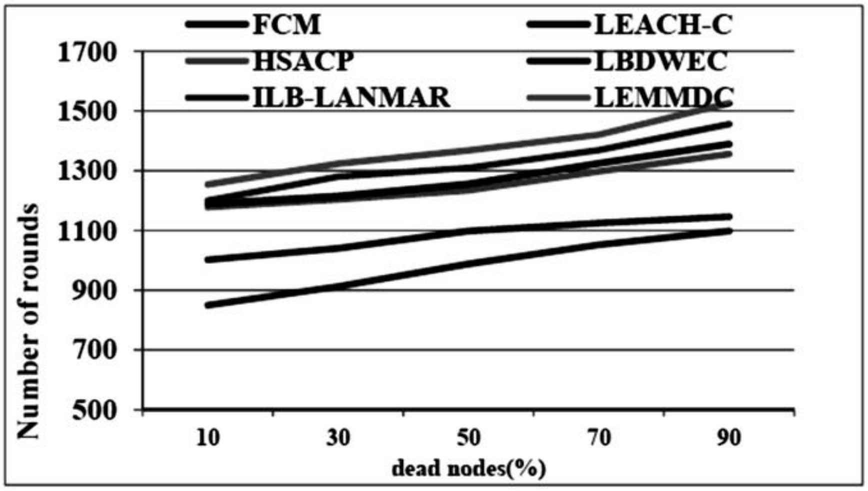

Figure 5: Comparison of the Number of Rounds as the Percentage of Dead Nodes Increases

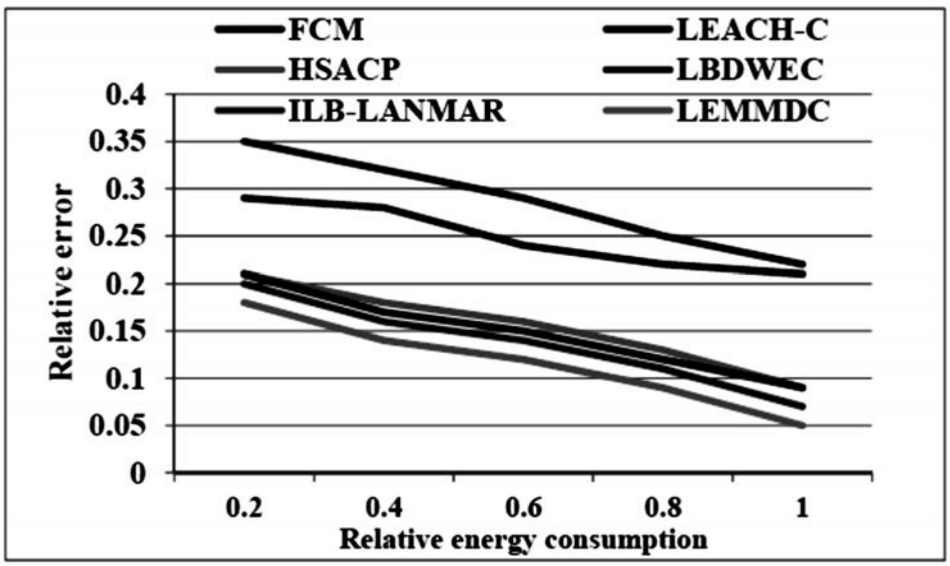

Figure 6: Reconstruction Accuracy and Energy Consumption

The above figure 6 represents the performance comparison of the energy consumption methods against relative error as measured in the proposed LEMMDC which are then later compared with the existing methods like ILB-LANMAR, LBDWEC, HSACP, FCM and LEACH-C. The results further proved that the proposed LEMMDC shows the least relative error for a given energy expenditure when compared to other existing methods.

5. CONCLUSION

Military communication is being considered as the most challenging task by various researchers as it requires the establishment of suitable routing method in a view to achieving highly reliable and secured data communication. In this research work, the proposed Load and Energy Aware Micro-Macro Density Clustering Approach (LEMMDC) method has offered remarkable routing scheme by means of clustering the group of mobiles nodes in terms of energy consumption level and the transmission range value. Furthermore, the density based clustering approach necessary for better and accurate clustering has also been employed and studied. Micro and macro clustering approaches also have supported military environment having a large number of mobile nodes. The performance evaluation of the numerical results of the proposed research method has been validated for its better results compared to various existing approaches.

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