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Development of a Clustered Network based on Unique Hop ID

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***Abstract*—In this paper, Land Marks for Unique Addressing(LMUA) algorithm is develped to generate unique ID for each and every node which leads to the formation of overlapping/Non overlapping clusters based on unique ID. To overcome the draw back of the developed LMUA algorithm, the concept of clustering is introduced. Based on the clustering concept a Land Marks for Unique Addressing and Clustering(LMUAC) Algorithm is developed to construct strictly non-overlapping clusters and classify those nodes in to Cluster Heads, Member Nodes, Gate way nodes and generating the Hierarchical code for the cluster heads to operate in the level one hierarchy for wireless communication switching. The expansion of the existing network can be performed or not without modifying the cost of adding the clusterhead is shown. The developed algorithm shows one way of efficiently constructing the multi hop non-overlapping clusters based on developed Unique ID.**

***Keywords*—**Cluster Dimension, Cluster Basis, Metric Dimension, Metric Basis.

I. Introduction

IN ad hoc networks, nodes are distributed randomly and they are identified by their unique IDs. In such a network, the execution of a leader election algorithm would result in the identification of only one node. If that node is the only node monitoring all other nodes, then the system no longer remains distributed but becomes centralized. Such a process will result in a single cluster and would require tremendous amount of transmission and computation power. Hence, we have to use a modified version of the leader election scheme. Instead of choosing only one leader, multiple nodes can be elected to perform the duties of the leader. Each of the leaders would be a leader with respect to a subset of the nodes- that is,it would have dominance over a set of nodes. Each leader would know who belongs to the set. This gives rise to the concept of clustering.

A cluster is similar to a ”group” in distributed systems. The nodes within the cluster are considered the member of a cluster head, a node has to lie within the transmission range of that cluster head. However, it is also possible that even if a node is within the transmission range of a cluster head, it may not belong to that cluster head. On the other hand, if a node falls within the transmission range of more than one cluster head, it is called a gateway node. A distributed gateway is a pair of neighboring nodes from different clusters physically located nearest to each other even though their clusters do not overlap.

Most cluster head election algorithms require that each node is a member of one cluster head and no two cluster heads are adjacent to each other. Thus, two cluster heads cannot be one-hop neighbors. Therefore, ad hoc networks make use of multiple clusters and require multiple cluster heads. Clusters may change dynamically, reflecting the mobility of the underlying network. The focus of the existing literature in this area has mostly been on partitioning the network into cluster [1], without taking into consideration the efficient functioning s of all the system components. Due to this dynamic nature of the mobile nodes, their association and dissociation to and from clusters perturb the stability of the network and thus reconfiguration of the cluster heads is unavoidable. This is an important issue since frequent cluster head changes adversely affect the performance of other protocols such as scheduling, routing and resource allocation that rely on it. The lack of rigorous methodologies applicable to the design and analysis of peer-to-peer mobile networks has motivated in-depth research in this area. There have been solutions for efficient ways of interconnecting the nodes such that the latency of the system is minimized while throughput is maximized [2]. Most of these approaches [3],[4],[2] for finding the cluster heads do not produce an optimal solution with respect to battery usage, load balancing and MAC functionality. Since choosing cluster heads optimally is an NP-hard problem [3], existing solutions to this problem are based on heuristic(most greedy) approaches and none of the attempts to retain the stability of the network topology [3].

We believe that a good clustering scheme should preserve the graph structure as much as possible when nodes are moving and/or the topology is slowly changing. Otherwise, re-computation of cluster heads and frequent information exchange among the participating nodes will result in high computation and communication overhead. Thus, optimal selection of cluster heads and partitioning of the nodes into clusters are essential aspects of mobile ad hoc networks.

II. Efficient non-overlapping clusters

To achieve efficient non-overlapping clusters based on unique Hop ID, the following features are to be addressed and solved. The algorithms are developed and presented here to construct strictly non overlapping clusters.

1)Generate unique ID for each and every node of a network(LMUA).

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2) Generate unique ID which satisfies the cluster dimension property to form non-overlapping clusters(LMUAC).
3) Identify those nodes which partition the network to form non-overlapping clusters(LMUAC).
4) Classify the nodes in a cluster(LMUAC).
5) Identify the gateway nodes in a network(LMUAC).
6) Generate unique code for CHs at 1 level hierarchy(LMUAC).
7) Switching between CHs at level 1 (w.r.t Source and Destination Hop ID)(LMUAC).

The below addressed algorithm explores the following features

- It operates efficiently in generating unique clustering Hop ID during off line condition($N - Tuple$) by (LMUAC).
- It provides full name based addressing, thus accommodating a percentage of nodes.
- It provides automatic address assignment, thus easing network administration.
- It accommodates administrative boundaries, providing control of routing paths, protection and autonomy.
- It helps in Formation of a non-overlapping clusters.
- It helps in identifying the type of nodes.
- Communication through cluster heads is adopted.

The purpose of an efficient Hop ID for clustering is to optimize routing in very large networks, the control is distributed in the networks, and the clustering Hop ID accomplishes this.

III. Basic Definitions

A. N-Tuple

Unique ID is an $N - Tuple$ $v(d_1, d_2, \ldots, d_n)$ associated with every node of the network where d_i represents the distance of the node from the i^{th} cluster head CH_i for $i = 1, 2, \ldots, n$.

Note 3.1: The i^{th} position value of length of the $N-Tuple$, say N, the $N-Tuple$ associated with the cluster head CH_i is zero. For $i = 1, 2, \ldots N$ defines the number of cluster heads in the cluster basis. The length of the Tuple, say N, is the cluster dimension of G.

B. Cluster

Clustering a set S is dividing the set into smaller subset $s_1, s_2, \ldots s_N$ such that $s_1 \cup s_2 \cup, \ldots s_N = S$. Each set s_i is called a clusters.

In this paper, the i^{th} cluster is the collection of all the vertices which are at minimum distance from the i^{th} cluster head $1 \leq i \leq n$. Equivalently it is the collection of these $N - Tuples$ which have the least entry in the i^{th} position $1 \leq i \leq n$.

Note 3.2: The clusters obtained by the above procedures are non-overlapping and non empty. The classification of the nodes inside a cluster using the $N - Tuple$ associated with the nodes as follows:

C. Classification of Nodes

1) Cluster Head: It is that node in the cluster which contains a 0 in its $N - Tuple$
2) Member Node: Every node which has the least entry in the i^{th} position of its $N - Tuple$ is a member node of i^{th} cluster, $i = 1, 2, \ldots, n$
3) Gateway Node: A gateway node in the i^{th} cluster,$i = 1, 2, \ldots, n$ is a member node in that cluster which has an adjacent node in the j^{th} cluster,$i \neq j$, $j = 1, 2, \ldots n$

Let n be the number of vertices in $V(G)$. Let $V(G) = \{v_1, v_2, \ldots, v_n\}$ be the vertex set of G. let $\{v_1, v_2, \ldots, v_N\}$ be the landmarks in the network. For any vertex v, $(Co-ordv)_j$ is the j^{th} Co-ord in the $N - Tuple$ for v and it is equal to $d(v, v_j)$, $1 \leq j \leq N$. For every vertex v, $N - Tuple(v)$ is the $N - Tuple$ of co-ordinates associated with v which is treated as address of v or Unique ID for v. Let $\beta(G)$ be the metric dimension of G, m is the metric basis of G, where N is an integer which is greater than or equal to metric dimension (number of landmarks), $N \geq |m|$. Where Pos is defined as the value of the integer t for which the t^{th} Co-ord is minimum in Co-ord of v and C_{min} is defined as, if Pos value is k, the value of the position v_i is the value of k^{th} Co-ord in $N-Tuple(v)$.

IV. Input Distance Matrix

The input of the network is taken in terms of the distance between two nodes rather than the adjacency or incidence. The purpose of representation of a network in terms of its distance matrix can be easily adopted for any type of network because the distance can be considered in various ways depending on the purpose in hand. For example the distance between two stations can be considered as air distance or for the land lines it may be length of the wire connection between two junctions to identify the fault in an exact location. The input can be easily modified for a weighted graph by considering the sum of weights on the edges in the shortest path as the distance between the corresponding nodes in the network. Throughout the algorithm we assume the network is a connected and represented by a square matrix $D = dist[i][j]$ of order n, where n is the number of nodes in the network and $dist[i][j]$ denotes the distance between the two nodes i and j. For any network the matrix D is a symmetric matrix with zero diagonal entry if and only if the network is undirected. The Algorithm IV-A is developed which is shown below

A. Algorithm for Input Distance Matrix

```
.Initialize dist[n][n]
Step 0: Reserve the memory for storing the distance:
n $\times$ n matrix is reserved
Step 1:Read the distance matrix:
For i=2 to n ..................Column
For j=1 to i-1 .................Row
dist[i][j]$\leftarrow$ Value
Exit
Step 2: Output
dist[i][j] is the distance between i$^{th}$ and j$^{th}$ vertex
$1 \leq i \leq n, 1 \leq j \leq i$
```

V. Generating Unique ID for vertices in a graph G (LMUA)

Throughout this paper, the graph is written as $G = (V, E)$ or simply G, to denote a graph on a finite non empty set V of vertices and E of edges. All the graphs considered in this paper are simple, finite, undirected and connected. For any two vertices u and v, the distance between u and v denoted by $d(u,v)$ is the length of the shortest path between them. The vertices in a graph G are to be identified uniquely in a given graph G. The purpose is to generate unique Hop ID $(N-Tuple)$ which is a multi coordinate system with respect to the pre selected landmarks. The co-ordinates associated with each node is based on the distance from the node to the randomly selected landmarks, the randomly selected landmarks must be just enough to generate a unique Hop ID $(N-Tuple)$ of co-ordinates. The coordinates of v_i vertices in a network with respect to N Landmarks are represented by $(N-Tuplev_i) = ((Co-ordv_i)_1, (Co-ordv_i)_2, \ldots, (Co-ordv_i)_N)$, For $1 \leq j \leq N$, $1 \leq i \leq n$, where $(Co-ordv_i)_N = d(v_i, u_j)$, where $u_j \leftarrow N^{th} Landmark$.

A co-ordinate system on G is defined as follows. Select a set N of nodes as the landmarks. For each landmark, the co-ordinate of a node $v_i \in V$ in G having the elements equal to the cardinality of the set N and j^{th} element of co-ordinate of v_i is equal to the length of shortest path from the j^{th} landmark to the vertex v_i in G. Here onwards Hop ID and $(N-Tuple)$ are interchangeably used for our convenience.

The aim of this Algorithm V-A is to find the minimum number of LandMarks (by randomly selected) required to generate Unique Hop ID Addressing (LMUA) for each and every node, which is shown below. The input is a distance matrix and initially let us assume that it has selected j landmarks and is still not able to generate the unique Hop ID. The Algorithm V-A is extended to generate unique Hop ID as follows. In step 0: The initialization has been carried out. In step 1: Selection of new landmark u_{j+1} is carried out randomly from the remaining set of vertices $\acute{V}$, the number of landmarks is increased, $N++$, the size of the metric basis element is also increased by adding the vertex u_{j+1} to its set. In step 2: The generated unique Hop ID with respect to the landmarks which are unique is verified. In step 3, the Algorithm V-A explores all the metric basis elements, minimum number of landmarks required which is $\geq \beta(G)$ and unique Hop ID generated for each and every vertex in a graph G which is essential for our purpose.

A. Algorithm for Metric Dimension(LMUA)

```
. Input distance matrix
$(Co-ordv_i)_j = d(v_i, u_j)$
j=1,2,3,. . . N
Step 0: .Initialize
.If the graph is not a path then $\beta(G) > 1$
.Suppose that $Co-ord_i = i^{th}$ Co-ord of a vertex, $1 \leq i \leq N$
$N-TupleV_i = ((Co-ordv_i)_1, (Co-ordv_i)_2, \ldots, (Co-ordv_i)_j)$
is already exist, $1 \leq j \leq N, 1 \leq i \leq n$
$.N\rightarrow \geq MetricDimension$
$.n\rightarrow$ Number of vertices in a graph G
.m $\rightarrow$ Metric basis elements set= $\{u_1, u_2, \ldots, u_j\}$
$.V_i\rightarrow$ Total number of Vertices in a graph G
V$_i = \{v_1, v_2, \ldots, v_n\}$,$1 \leq i \leq n$
$\acute{V} = V - m$, remaining number of vertices for selection of Metric basis
Step 1: Selection of Metric Basis Element to generate unique ID.
Select a vertex $u_{j+1}$ at random from ,$N = j+1$,$m\{\} \leftarrow m\{\} \cup u_{j+1}$
$m = \{u_1, u_2, \ldots, u_j, u_{j+1}\}$
$[(Co-ordu_{j+1}) = 0]$
Generate N Tuple $v_i$,N=j+1,$1 \leq i \leq n$..Code for rest of vertices
Step 2: Identify Unique ID.
For 1$\leq i \leq n$
(Co-ord v$_i)_{j+1} = d(v_i, u_{j+1})$
For $1 \leq i \leq n-1$
For $i+1 \leq \acute{i} \leq n$
If $((NTuple \quad v_i) == (NTuple \quad \acute{v_i})), i < \acute{i}$
{N++, Go to step 1}
Else Exit
Step 3:Output
$m = \{u_1, u_2, \ldots u_j, u_{j+1}\}$ ...............Metric Basis Elements.
$N = \{int\} \geq \beta(G)$ ..................Metric Dimension.
N Tuple $v_i, 1 \leq i \leq n$ ...............Unique ID for all the vertices of V.
```

The following example demonstrates how to generate unique Hop ID for each and every network for a given graph of G. Let L_1, L_2 and L_3 be the land marks selected in a graph G of 29 vertices to generate unique Hop ID , let $N = 3$, $m = \{L_1, L_2, L_3\}$ the first Co-ord associated to each and every node is the shortest distance from first landmark i.e, L_1, the generated unique $(N-Tuplev_i)$ is not unique we know that the graph is not a path. So the second land mark L_2 is selected randomly from the remaining set of vertices of G and the second Co-ord associated to each and every node is the shortest distance from the second landmark i.e, L_2 the generated unique $(N-Tuplev_i)$ is also not unique, so the third landmark L_3 is randomly selected from the remaining set of vertices of G and the length of the $Co-ord$ is three and the third $Co-ord$ is the distance from the third landmark which satisfies the concept of metric dimension, where $N \geq \beta(G)$, which is shown in Figure 1. Which gives the upper bound of the metric dimension. The output of the LMUA Algorithm is shown in the Table I.

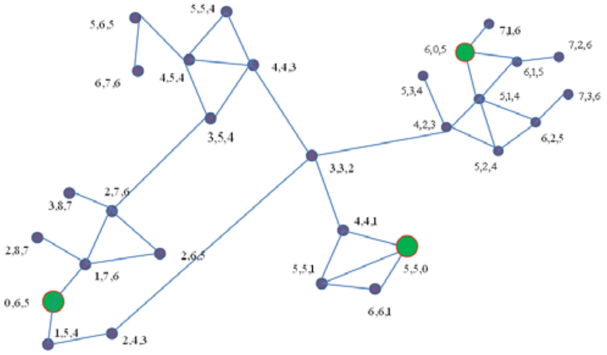

Fig. 1. Unique Hop ID by LMUA

TABLE I
OUTPUT OF THE LMUA ALGORITHM

Characteristics of the LMUA Algorithm	
Concept	Resolving Set,Doubly resolving set
n	29
N	3
m	$\{L_1, L_2, L_3\}$
N	$\geq \beta(G)$
$(N-\text{Tuple} \quad u)$	Unique
Clusters	Overlapping/Non Overlapping
Disadvantages	Overlapping Clusters
Applications	Robot Navigation,Network verification, Network Discovery
Complexity	NP hard problem -General
Complexity $\beta(G) = 2$	$\left(\frac{n(n-1)}{2} D^4\right)$
$\lvert V\rvert$	$\geq C_1 \cup C_2, \ldots, C_N$
$\lvert V\rvert_{\beta(G)=2}$	$\geq n$

VI. Clustering the graph using Hop ID

A successful approach for dealing with the maintenance of mobile ad hoc networks is by partitioning the network into clusters. In this way the network becomes more manageable. It must be clear though that a clustering technique is not a routing protocol. Clustering is a method which aggregates nodes into groups [5]. These groups are contained in the network and they are known as clusters. A cluster is basically a subset of nodes of the network that satisfies a certain property [6]. Clusters are analogous to cells in a cellular network. However, the cluster organization of an ad hoc network cannot be achieved off line as in fixed networks [7]. Clustering presents several advantages for the medium access layer and the network layer in MANET [8]. The implementation of clustering schemes allows a better performance of the protocols for the Medium Access Control (MAC) layer by improving spatial reuse, throughput, scalability and power consumption. On the other hand, clustering helps improve routing at the network layer by reducing the size of the routing tables and by decreasing transmission overhead due to the update of routing tables after topological changes occur [9],[6]. Clustering helps aggregate topology information since the number of nodes of a cluster is smaller than the number of nodes of the entire network. Therefore, each node only needs to store a fraction of the total network routing information [10].

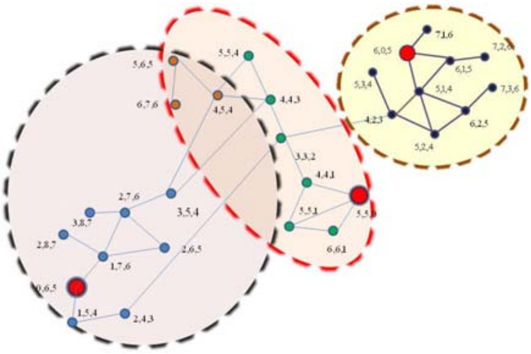

Fig. 2. Clustering by unique hop ID(LMUA)

Our proposed routing protocol is based on the formation of clusters, hence efficient cluster formation will be the crux of the routing protocol of this nature. Cluster should be formed in such a way that the resulting graph is cluster connected. Routing from one node to another will consist of routing inside a cluster and routing from cluster to cluster. The $N-Tuplev_i$ generated for each and every vertices in a graph G for the above example is unique, for $1 \leq i \leq n$. The vertices of a graph G are to be strongly resolved by one and only one landmark by the definition of the cluster dimension. The strongly resolving set is considered are as follows, the nodes are strongly resolved by the landmark L_1 if the value of the first digit in the $N-Tuplev_i$ Hop ID is the least. Similarly the nodes are strongly resolved by a landmark L_2 if the value of the second digit in the $N-Tuple \quad v_i$ is the least. This process is carried out for all the landmarks and the resultant of the above graph is the formation of the overlapping clusters which is a draw back in the clustered network. The nodes which are not strongly resolved by one of the land marks; therefore the role of that member node becomes difficult (like making decision, control overhead) as to with which cluster it has to communicate and, if it is resolved by more than one landmarks the control is with more than one landmarks so it is a complicated member node. To avoid such type of nodes in a network we should satisfy the cluster dimension property. The above Figure 2 demonstrates that the unique ID generated using the concept of the metric dimension is insufficient.

VII. Definition:Clustering

Definition 7.1: 1) Let $G = (V, E)$ be a graph representing the given network. A clustering is a specific method of dividing the vertex set $V(G)$ according to the convenience of the user. For our purpose, the clusters are non intersecting, non empty subsets of $V(G)$. whose union is equal to $V(G)$.

2) The basic tool to introduce clusters in $V(G)$ is a 'metric' which is the shortest hop count distance between the nodes.
3) To every vertex, a unique clustering ID is generated which satisfies the properties given in definition **??**.
4) The J^{th} cluster, say C_j contains vertex v_i, with ID $((Co-ordv_i)_1, (Co-ordv_i)_2, \ldots, (Co-ordv_i)_N)$, such that $(Co-ordv_i)_j < (Co-ordv_i)_k) \forall k \neq j$, $k = 1, 2, 3, \ldots, N$.

Tthe concept of metric dimension is extended by adding an additional property that each unique ID is to be strongly resolved by one and only one cluster. To achieve this an additional landmark L_4 is randomly selected to generate unique clustering Hop ID for clustering the network. The following algorithm generate unique clustering Hop ID which satisfies the definition of cluster dimension. This algorithm explores all the cluster basis elements, Cluster Dimension and $N-Tuplev_i$, for $1 \leq i \leq n$.

Theorem 7.1: Between any two cluster heads, if there is a path of length two then the vertex which is at a distance one from both the cluster heads must be another cluster head.

Proof: Let there be a path of length two between the cluster heads say v_i & v_j. Let u be adjacent to both v_i & v_j on the above path. If u is not a cluster head, then u is not strongly resolved by any of the vertices in G by Definition of 7.1. Hence u must be a cluster head. ■

Theorem 7.2: Between any two clusters heads if there is a path of length three then the intermediate vertices on the path are the gateway nodes.

Proof: Similar to the above proof 7.1. ■

Note 7.1: On any path between the given two cluster heads there is a non gateway member node. If the length of the path is greater than three.

A. Algorithm for Cluster Dimension (LMUAC)

The aim of this Algorithm which is shown below is to generate Unique ID for each and every node which is dominated by one and only cluster head. To satisfy this condition the above Algorithm V-A developed is insufficient, which constructs either overlapping/non-overlapping clusters, which makes those nodes which are dominated by more than one cluster heads. The out put of this algorithm is shown below, which has generated an unique ID.

```
Input distance matrix
$(Co - ordv_i)_j = d(v_i, u_j)$
j=1,2,3,. . . N
Step 0: .Initialize
.If the graph is not a path then $\beta_c(G) > 1$
.Suppose that $Co - ord_i = i^{th}$ Co-ord of a vertex, $1 \leq i \leq N$
$N - TupleV_i = ((Co - ordv_i)_1, (Co - ordv_i)_2, \ldots, (Co - ordv_i)_j)$
is already exist, $1 \leq j \leq N, 1 \leq i \leq n$
.$N \rightarrow \geq$ Cluster Dimension
.n $\rightarrow$ Number of vertices in a graph G
.m $\rightarrow$ cluster basis elements set= {u$_1, u_2, \ldots, u_j\}$
.$V_i \rightarrow$ Total number of Vertices in a graph G
V$_i = \{v_1, v_2, \ldots, v_n\}$,$1 \leq i \leq n$
$\acute{V} = V - m$, remaining number of vertices for selection of cluster basis
Step 1:Select ClusterBasis Element to generate uniqueID from $\acute{V}$.
Select a vertex $u_{j+1}$ at random from ,$N = j + 1$
[$(Co - ordu_{j+1}) = 0$]
$m\{\} = m\{u_1, u_2, \ldots, u_j\} + u_{j+1}$
$m = \{u_1, u_2, \ldots, u_j\ u_{j+1}$
Generate N Tuple $v_i$,N=j+1,$1 \leq i \leq n$..Code for rest of vertices
Step 2: Generate $C_{min}$ to satisfy Cluster Dimension Definition.
For 1$\leq i \leq n, False = 0, pos$
C$_{min} = (Co - ordNTuple\ \ v_i)_1$
For 2$\leq j \leq N$
$If($C$_{min} = (NTuple\ \ v_i)_j)$
{False=1}
ELSE IF $(C_{min} < (NTuple\ \ v_i)_j)$
{continue
ELSE $C_{min} \leftarrow (NTuple\ \ v_i)_j)$, False=0, pos=j
If (False=1), go to step 1
ELSE
(Co-ord N Tuple $v_i)_(N + 1) \leftarrow pos$
Step 3: Identify Unique ID.
For 1$\leq i \leq n$
(Co-ord v$_i)_{j+1} = d(v_i, u_{j+1})$
For $1 \leq i \leq n - 1$
For $i + 1 \leq \acute{i} \leq n$
If $((NTuple\ \ v_i) == (NTuple\ \ \acute{v_i})), i < \acute{i}$
{N++, Go to step 1}
Else Exit
Step 4:Output
$m = \{u_1, u_2, \ldots u_j, u_{j+1}\}$ ........Cluster Basis Elements.
$N = \{int\} \geq \beta_c(G)$ ................Cluster Dimension.
N Tuple $v_i$, $1 \leq i \leq n$ .........Unique ID for all the vertices of V.
pos ...............the position value of $C_{min}$ in N Tuple $v_i$.
```

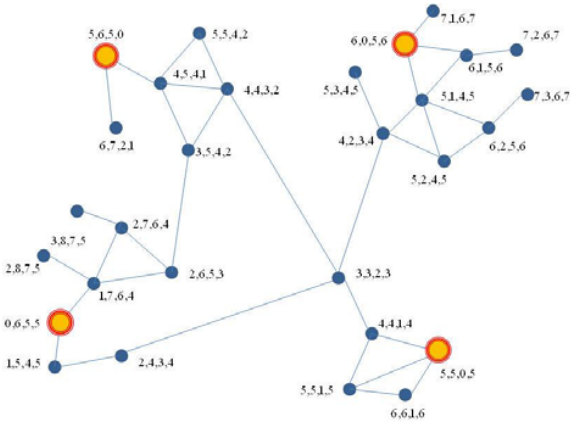

Fig. 3. Unique ID generated by LMUAC

VIII. Formation of non-overlapping clusters.

The aim is to form non-overlapping clusters for an efficient communication, which leads to reduction in routing Table size, communication overhead and information of only neighbor nodes. The following algorithm is used to carry out strictly non-overlapping clusters with the help of unique clustering Hop ID which is shown in the Figure below which satisfies cluster dimension property. The unique $N - Tuplev_i$ of the vertices for $1 \leq i \leq n$ is clustered. The first $(Co - ordv_i)$ is least then they are all strongly resolved by the first landmark L_1 and available in C_1 and the second $(Co - ordv_i)$ is least then it is strongly resolved by the second landmark L_2 and available in C_2. Similarly the procedure follows for all the land marks. None of the nodes are strongly resolved by more than one of the land marks and none of the member nodes belong to more than one cluster. The resultant is, it forms non-overlapping clusters. Each and every cluster has one and only one landmark and the resultant is $C_1 \cup C_2 \cup C_3 \cup C_4 = V$.

TABLE II
Output of LMUAC Algorithm

Characteristics of the LMUAC Algorithm	
Concept	Strongly Resolving Set
n	29
N	4
m	$\{L_1, L_2, L_3, L_4\}$
$\acute{N}$	$\geq \beta_c(G)$
$(N -$ Tuple $\ u)$	Unique
Clusters	Non Overlapping
Disadvantages	Number of landmarks is more
Applications	Cluster for communication, Hierarchical routing
Complexity	NP hard problem -General
Complexity $\beta_c(G) = 2$	$\left(\frac{n(n-1)}{2} D^4\right)$
$\|V\|$	$= C_1 \cup C_2, \ldots, C_N$
$\|V\|_{\beta_c(G)=2}$	$= n$

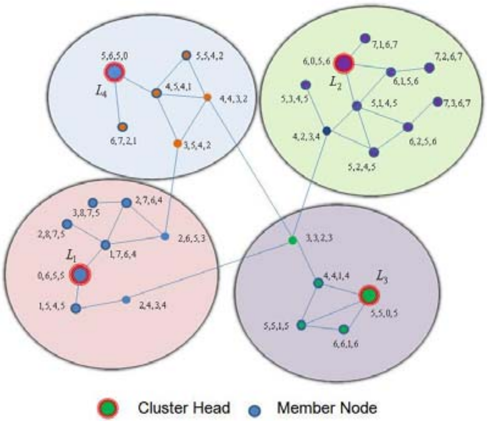

Fig. 4. Construction of Non Overlapping Clusters(LMUAC)

IX. Classification of nodes in a cluster based on Hop ID

Clustering is a method which aggregates nodes into groups [5]. These groups are contained in the network and they are known as clusters. A cluster is basically a subset of nodes of the network that satisfies a certain property. A cluster is a collection of nodes like Cluster Head and a Member node. These nodes are classified into member node and cluster head. Member nodes are members of a cluster which do not have neighbors belonging to a different cluster. Most clustering approaches for mobile ad hoc networks select a subset of nodes in order to form a network backbone that supports control functions. A set of the selected nodes are called cluster heads and each node in the network is associated with one. Clusterheads are connected with one another directly or through gateway nodes. The union of gateway nodes and clusterheads form a connected backbone. This connected backbone helps simplify functions such as channel access, bandwidth allocation, routing power control and virtual-circuit support [11]. Clusterheads are analogous to the base station concept in current cellular systems. They act as local coordinators in resolving channel scheduling and performing power control [2]. However, the difference of a clusterhead from a conventional base station resides in the fact that a clusterhead does not have special hardware, it is selected from among the set of stations and it presents a dynamic and mobile behavior [14]. Since clusterheads must perform extra work with respect to ordinary nodes they can easily become a single point of failure within a cluster. For this reason, the clusterhead election process should consider for the clusterhead role, those nodes with a higher degree of relative stability [5]. The main task of a clusterhead is to calculate the routes for long-distance messages and to forward inter-cluster packets. A packet from any source node is first directed to its clusterhead. If the destination is in different clusters then the switching between the cluster heads is carried out.

The procedure adopted here to classify the nodes for a given cluster which consists of a subset of nodes. The pos value is the same for all the nodes, the $(N - Tuplev_i)_{N+1} = ((Co - ordv_i)_1, (Co - ordv_i)_2, \ldots, (Co - ordv_i)_N, pos)$, $C_j\{n_1, n_2, n_3, n_k\}$, $n_k \in C_j$, $1 \leq k \leq \acute{k}$, $1 \leq j \leq N$. The vertex with $(Co - ordv_i)_j = 0$ is treated as a cluster head of that cluster $C_j\{\}$ and the vertex with $(Co - ordv_i)_j \neq 0$ is treated as a member node of that cluster $C_j\{\}$. The classification of the nodes in a cluster is carried out and it is shown in figure 5.

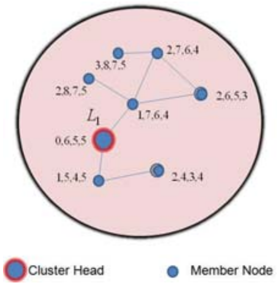

Fig. 5. Construction of Clusters(LMUAC)

X. Identification of Gateway nodes in a network

Gateway nodes are nodes in a non-clusterhead state located at the periphery of a cluster. These types of nodes are called gateways because they are able to listen to transmissions from another node which is in a different cluster [10]. To accomplish this, a gateway node must have at least one neighbor that is a gateway of another cluster [12]. The following algorithm is used to identify the gateway nodes in a network. The $d(u_j, v_j) = 1$ and the position value of v_j and u_j is different then they are treated as a gateway node in a network. The algorithm takes care of identifying gateway nodes in a network. For the algorithm 6 shows the identification of gateway nodes in the considered example.

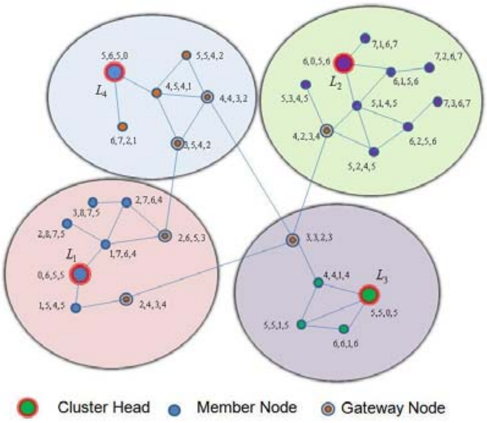

Fig. 6. Identification of Gateway nodes in a Network(LMUAC)

XI. Hierarchical address for the cluster heads in clustered network

Hybrid routing provides routing through the implementation of a hierarchical approach [13]. In a hierarchical approach the network is organized into subsets of nodes, known as clusters. This topology organization reduces network traffic because a node only needs to have knowledge of the routing information within its cluster and not of the entire network. Hybrid routing, also known as cluster-based routing is a convenient scheme for developing efficient routing algorithms in MANET. Apart from making a large network appear smaller, one significant feature of cluster-based routing is that it can make a dynamic topology appear less dynamic [7]. In order to implement a dynamic hybrid routing scheme, efficient clustering algorithms must be designed. After clustering, each node in the hierarchy can be assigned a hierarchical address that indicates its position in each level of the hierarchy. Routing can easily be carried out using such addresses. The example from [5] to explain this. A n-node network with three hierarchy levels is created by recursive clustering. The terms Level-0 to refer to the original network, Level-1 to refer to the structure obtained by clustering once, and Level-2 to refer to the structure obtained by clustering Level-1. Each node in the network can be assigned a n-level hierarchical address.

The input is a $CH_j\{\}$ which is a non empty set and it contains only one vertex in it. Now our aim is to generate the hierarchical code for the cluster heads of that cluster. The process of generating the unique code at the level 1 is given by for a given $CH_j\{\} = (Co - ordv_k)_j = 0 \rightarrow 0$ and $(Co - ordv_k)_i \neq 0 \rightarrow 1, i \neq j$ the length of the tuple is N,$1 \leq i \leq N$. The algorithm 6 is used to generate the unique code for the cluster head at level 1 hierarchy. The Figure 7 shows the hierarchical code for the example.

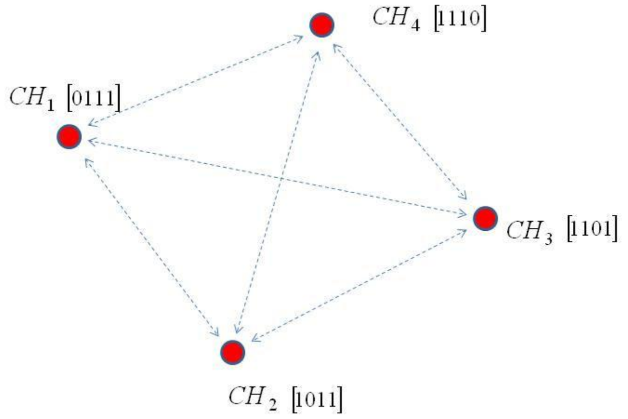

Fig. 7. Generating unique code for CH at 1 Level hierarchy(LMUAC)

XII. Expansion of existing network (Adding a new node):

Let $G = (V, E)$ be the graph representation of the existing network. Let $C_1, C_2, C_3, \ldots, C_N$ be the N clusters of $V(G)$ and $v_1, v_2, \ldots, v_N$ be the corresponding cluster heads. The possibility of adding a new vertex to any vertex of any cluster through one edge is explored. It is done so that there will be no change in the existing clusters(except that the corresponding clusters to which, the adding of a new vertex has one more edge and one more vertex) and no change in cluster heads. We first state and prove a theorem and then give an algorithm to check whether a vertex can be added to the given vertex of the given network.

Theorem 12.1: Let $G(V, E)$ be the graph representation of a given network. Let $C_1, C_2, C_3, \ldots, C_N$ be the clusters and $v_1, v_2, \ldots, v_N$ be the corresponding cluster heads. A new vertex u can be added to a vertex v in the cluster C_j, $1 \leq j \leq N$ through a single edge if and only if the unique clustering ID generated to the vertex u is not the same as unique clustering ID of any vertex in V_d if exists, where $V_0, V_1, V_2, \ldots, V_d, \ldots, V_{e(v_j)}$ is the distance partition of $V(C_j)$ with respect to the vertex v_j and $d(v_j, u) = d$.

Proof: As the $(Co - ordN - Tupleu)_j$ is the unique clustering ID of u it cannot be same as unique clustering ID of any vertex in any cluster $C_i, i \neq j$. In C_j, all the vertices w are at distance d from the cluster head v_j hence the same value of $(Co - ordN - Tuplew)_j$ as $(Co - ordN - Tupleu)_j$ because $d(v_j, u)$. If for some such vertex x, all the $Co - ordN - Tuple$ in the unique clustering ID are same as corresponding $Co - ordN - Tuple$ of u in its unique clustering ID, then the vertices x and u are not strongly resolved by any of the cluster heads, then u cannot be added through a single edge. If the above is not the case then u can be added to C_j, through a single edge. ■

Example:Addition of a vertex $x/\acute{x}$.

Case(i) If $d(u, CH_1) > e(CH_1)$.

Consider the Figure 5. Let C_1 be a cluster and $e(CH_1) = 3$ as shown in Figure5. Let x be a new vertex to be added to the cluster c_1 in the existing network through a single edge. Let x be a vertex which is at a distance greater than the $e(CH_1)$ with respect to CH_1. From the Figure the $e(CH_1) = 3$. Let u be the only vertex which is at distance 3 from CH_1 from the Figure. The new vertex to be added to the existing cluster C_1, which is at a distance 4. The distance of vertex x is greater than the $e(CH_1)$, then the new vertex should be adjacent to the only vertex u which is at distance three from the CH_1. The $N - Tuple$ of u from the Figure is (3875). The new vertex which is adjacent to the vertex u will have the $(N - TupleCo - ord)$ of (4986). The new $(Co - ord)$ of x generated is by incrementing $N - Tuple$ of u by 1. The newly generated $N - Tuple$ of x is strongly resolved by CH_1 and $x \in C_1$. The newly added vertex which is at 4 hop distance from the cluster head which is $> e(CH_1)$. Then add this new vertex through the single edge. The new vertex x to be added to the existing cluster without modifying the cluster head numbers and cluster structure is verified. Consider the distance partition of the cluster C_1 with respect to the cluster head L_1, parallel consider the new vertex to be added to the existing cluster C_1 with respect to cluster head L_1 separately. Find the intersection of $L_1 \cap x$. From the above theorem 12.1if $L_1 \cap x = 0$. Then add the new vertex to the cluster C_1 without any modification of the cluster structure. Update the $e(CH_1)$ and adjacent vertex to which the new vertex added through the single edge neighbor member Table. The Table XII shows the update structure.

Distance partition with respect to L_1 with vertex x.

Case (ii) If $d(\acute{x}, CH_1) < e(CH_1)$.

TABLE III
Distance partition with respect to L_1 with vertex $x \geq e(C_j)$.

$d(CH_1)$	L_1	x	$L_1 \cap x$
1	(1545),(1764)	-	-
2	(2434)(2653)(2764)(2875)	-	-
3	(3875)(3545)	-	-
4	-	(4986)	-

Let $\acute{x}$ be a new vertex which is at a distance d from cluster head L_1. Let $d < e(CH_1)$, then the new vertex $\acute{x}$ should be adjacent to one of the vertices in the cluster C_1. Let v be a vertex, which is at 2 hops from cluster head L_1 which is less than the eccentricity of the CH_1. From the Figure let v have N_Tuple value (2764). Let $\acute{x}$ be adjacent to vertex v, then the new $Co - ord$ of $\acute{x}$ generated is by incrementing N_Tuple of v by 1. The newly generated $N - Tuple$ of $\acute{x}$ is (3875) which is strongly resolved by CH_1 and $\acute{x} \in C_1$. The newly added vertex which is at 3 hop distance from the cluster head which is $\leq e(CH_1)$. Then add this new vertex through the single edge. The new vertex $\acute{x}$ to be added to the existing cluster without modifying the cluster head numbers and cluster structure is to be verified. Consider the distance partition of the cluster c_1 with respect to the cluster head l_1, parallel consider the new vertex $\acute{x}$ to be added to the existing cluster C_1 with respect to cluster head L_1 separately. Find the intersection of $L_1 \cap \acute{x}$.

From the above theorem if $L_1 \cap \acute{x} = 1$. Then the addition of a new vertex to the cluster C_1 is not permitted. The Table XII shows the update structure. The example shows the addition or deletion of a node in a cluster which is shown the Figure 8.

TABLE IV
DISTANCE PARTITION WITH RESPECT TO L_1 WITH VERTEX $\acute{x} \leq e(C_j)$.

$d(CH_1)$	L_1, CH_1	$\acute{x}$	$L_1 \cap \acute{x}$
1	(1545),(1764)	-	-
2	(2434),(2653),(2764),(2875)	-	-
3	(3875)(3545)	(3875)	1

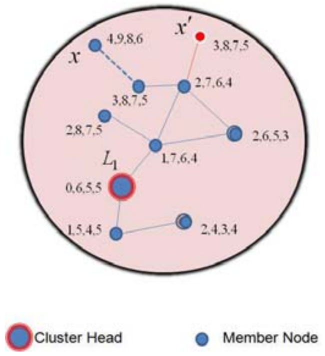

Fig. 8. Addition of a vertex in a cluster

XIII. CONCLUSION

In this paper, Land Marks for Unique Addressing(LMUA) algorithm is develped to generate unique ID for each and every node which leads to the formation of overlapping/Non overlapping clusters based on unique ID. To overcome the draw back of the developed LMUA algorithm, the concept of clustering is introduced. Based on the clustering concept a Land Marks for Unique Addressing and Clustering(LMUAC) Algorithm is developed to construct strictly non-overlapping clusters and classify those nodes in to Cluster Heads, Member Nodes, Gate way nodes and generating the Hierarchical code for the cluster heads to operate in the level one hierarchy for wireless communication switching. The expansion of the existing network can be performed or not without modifying the cost of adding the clusterhead is shown. The developed algorithm shows one way of efficiently constructing the multi hop non-overlapping clusters based on developed Unique ID.

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