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Proximity Based Hierarchical Clustering with Neighbor Aware Stable Link Communication for Mobile Ad hoc Network

P.Tamilselvi[1*], T.N.Ravi[2]
[1]PG and Research Department of Computer Science, Periyar E.V.R. College (Autonomous)
(Affiliated To Bharathidasan University),Tiruchirappalli, Tami lNadu, India
[2,] PG and Research Department of Computer Science, Periyar E.V.R. College (Autonomous)
(Affiliated To Bharathidasan University),Tiruchirappalli, Tamil Nadu, India
*tamilselvip.it@cauverycollege.ac.in
[2]proftnravi@gmail.com

ABSTRACT

Mobile ad hoc networks are becoming increasingly important in industrial and commercial applications as new technologies emerge. The MANET's highly dynamic topology configuration allows it to be used in military and disaster management applications. A huge deployment of MANETs includes high volume of nodes which creates a bigger challenge in terms of network establishment and network management.The clustering algorithm organizes mobile nodes into groups of objects that are identical. Identifying the stable route in a complex topology segment is also a major challenge. By combining the agglomerative clustering technique with proximity computation, the proposed algorithm establishes the network structure. The link connectivity is monitored using Neighborhood Discovery Protocol (NHDP) to improve the stability.The proposed algorithm allows for secure contact between clusters and within clusters. The currently disconnected connections are being tracked and reported towards the next neighbor. The number of clusters formed and the connection delay for inter-cluster communication are used in the simulation (PHC-NSL) of this technique. The results show that the (PHC-NSL) technique is more efficient than the start-of-art methods.

Keywords
Agglomerative, Hierarchical clustering, Proximity, NHDP, Link connectivity

Introduction

A mobile ad hoc network is a wireless communication network that is created without the use of a central administrator. The network's nodes communicate directly using single hop communication or indirectly using multihop communication through intermediate nodes. The dynamic topology properties present a significant challenge in the route discovery process. In a large-scale setting, all nodes on the network must be maintained. Since maintaining all nodes on a large network is a tedious task in a large scale setting, a clustering approach is used to maintain the nodes on the network[1]. Clustering is the process of grouping nodes into groups based on their similarity. The aim of cluster formation is to structure the network. Inter-cluster communication and intra-cluster communication are both challenges in clustering process. To build the cluster, the proposed approach uses the Agglomerative Hierarchical Clustering algorithm. Intra cluster communication is determined by proximity value computation; inter cluster communication is accomplished using the NHDP protocol, which tracks link connectivity connectivity in between cluster communication as well as within cluster. The improved performance is accomplished due to the stable link connection.

Literature Review

The proposed Dynamic Direction Vector Hop algorithm[2] uses the direction range and speed limit to form clusters for the base station. The cluster head node shares data on a regular basis to keep the cluster together. Using the distance between the cluster head node and the cluster member node, direction, and velocity, a cluster member node calculates the exchange probability for the cluster head node. Based on the estimated likelihood of cluster participants, the cluster head node chooses the cluster member node with the highest probability.

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The author present a parametric analysis for efficient MANET clustering and cluster-based routing for a particular disaster scenario. The first part focuses on cluster creation, while the second part uses a neural network to provide protection [3].

In a group application program, the output of a clustering algorithm is examined. After evaluating the mobility module's characteristics with the traditional clustering algorithms, six major one-hop clustering algorithms are compared and evaluated using group communication mobility module RPGM in the paper[4].

In the proposed cluster generation algorithm [5] number of cluster member is considered as a metric.The highest number of cluster member holding node is elected as the cluster head. Number of cluster head election is reduced only one associate node leads the communication between cluster head nodes.In order to keep the number of cluster heads to a minimum, this scheme also proposes the cluster merging algorithm. The proposed cluster repair algorithm will repair a damaged cluster.

Sankar et al. proposed [6] an energy-efficient clustering protocol that uses a radial basis feature to select cluster heads. The trust value is used to identify malicious nodes. Message drop and energy consumption are avoided according to the confidence value.

The RMCMS strategy proposed by Jaber Ibrahim Naser et al. [7] aims to minimize the amount of times cluster information is transmitted from the CH nodes to the SDN controller in order to reduce CH node power consumption and overall network overhead. It works on the principle of supply and demand. As a result, information from CH nodes to SDN controllers is not transmitted on a regular basis.

When using a cluster-based routing protocol in a MANET, energy is a major concern [8]. (Mobile Ad hoc Network). If a cluster head dies, a new cluster head must be chosen using the re-clustering process. This technique, which requires explicit message passing between nodes once more, will increase power consumption and reduce overall system performance.

This paper proposes a clustering algorithm based on a memetic algorithm (MA) [9]. MA uses local discovery strategies to reduce the likelihood of early convergence. Before moving on to other evolutionary algorithms, MA's local search function aims to find the best local solution. MANET's best clusters can be built using MA for dynamic load balancing.

For efficient message routing from source to destination, RIMCA is a cluster-based solution [10]. In RIMCA, a mobile adhoc network (MANET) is made up of mobile wireless nodes that randomly move across the cluster. The communication between these mobile nodes is done without any centralized control per cluster, but communication between nodes in different clusters is done using border cluster node.

Proposed Methodology

Proximity Based Hierarchical Clustering with Neighbor Aware Stable Link Communication (PHC-NSL)

A mobile ad hoc network is defined as a collection of autonomous mobile nodes connected by wireless links. As it is a self-organizing, self-healing architecture, the mobile nodes have been calibrated to form a network without any infrastructure. The network nodes communicated with one another via the intermediate nodes. Because of the network's dynamic topology, nodes move in any direction at irregular intervals. Route discovery and node communication are considered difficult tasks. When the network has a high density of nodes, the proposed methodology employs the most systematic strategy known as clustering to improve the discovery process.

Network Model

A MANET is comprised of all nodes that exist in a ‘n*n' two-dimensional squared scenario and communicate via a transmission range ‘t_r' as shown in Figure 1. The distance measure is used to identify neighboring nodes prior to route discovery. Consider the coordinates of a mobile node in two dimensions are represented as (u_1,v_1) (u_2,v_2). Table 1depicts the coordinated values.

The distance between the two mobile nodes are mathematically evaluated as,

$$\boldsymbol{D_{mn} = \sqrt{(u_2 - u_1)^2 + (v_2 - v_1)^2}} \quad \textbf{(1)}$$

Where, D_{mn} is represents the distance between the two mobile nodes to find the neighboring nodes in the network.

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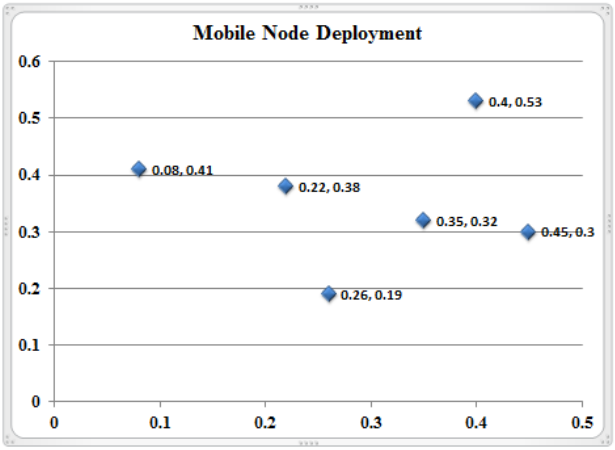

Figure 1: Network Model

Table 1: Coordinate Values

Mobile Node	X-Coordinate	Y-Coordinate
MN_1	0.4	0.53
MN_2	0.22	0.38
MN_3	0.35	0.32
MN_4	0.26	0.19
MN_5	0.08	0.41
MN_6	0.45	0.3

The proposed method PHC-NSL is divided into four phases that are all interconnected. They are depicted in Figure 3.

1. Cluster formation
2. Proximity Computation
3. Intra Cluster Communication
4. Inter Cluster Communication

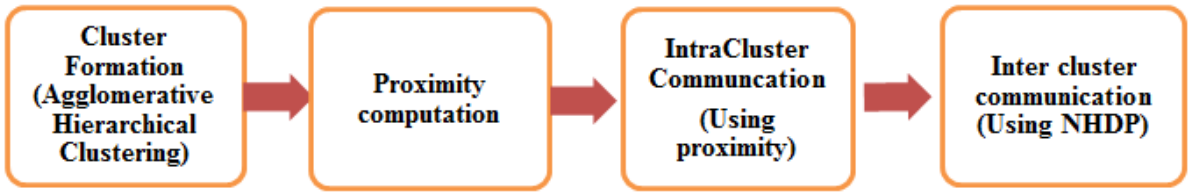

Figure 3 : Proximity Based Hierarchical Clustering with Neighbor Aware Stable Link Communication (PHC-NSL)

Cluster Formation using agglomerative clustering algorithm

The Agglomerative Hierarchical clustering method is used to improve the scaling process. Intra clustering communication is accomplished by computing the proximity of two points located in different clusters. The implementation of the Neighborhood discovery protocol allows for inter-cluster communication (NHDP) Agglomerative clustering is the most common type of hierarchical clustering, and it is used to group objects into clusters based on their similarity. To begin, the algorithm treats each object as if it were a singleton cluster. Then, one by one, pairs of clusters are merged until all clusters have been merged into one large cluster containing all objects. The finished product is built as a tree-like structure known as a dendrogam.. Figure 6 depicts cluster formation, while Figure 7 depicts the dendrogram or tree-like structure.

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Proximity Computation

Based on the nearest nodes, farthest nodes, and pairwise nodes in separate clusters, the proximity value is computed to evaluate cluster to cluster communication. Min proximity is defined as the distance between the closest nodes, max proximity is defined as the distance between the farthest nodes, and group average is defined as the distance between pairwise nodes in different clusters as represented in fig 4. The Euclidian distance matrix shown in Table 2 is used to calculate proximity.

Proximity Minimum (Single Link) **: S**hortest distance between two cluster's end points.
Maximum Proximity(Complete Link) : Maximum distance between two cluster's end points
Group Average **:** The average pairwise similarity of all pairs of points from different clusters is called the average pairwise proximity. Defined using Equation (2)

$$\boldsymbol{Proximity}(\boldsymbol{C_{i,}C_j}) = \sum_{x\in C_i, y\in C_j} \frac{\sum_{x\in C_i, y\in C_j} \boldsymbol{Proximity}\,(C_i, C_j)}{M_i * M_j} \qquad \textbf{(2)}$$

Where $C_{i,}C_j$ denotes the clusters and $M_i * M_j$ is called as the size of the cluster. The PHC-NDL forms the cluster using single link proximity the cluster formation and dendrogram is

Table 2 : Euclidian Matrix Computation

	MN_1	MN_2	MN_3	MN_4	MN_5	MN_6
MN_1	0	0.24	0.22	0.37	0.34	0.23
MN_2	0.24	0	0.15	0.20	0.14	0.25
MN_3	0.22	0.15	0	0.15	0.28	0.11
MN_4	0.37	0.20	0.15	0	0.29	0.22
MN_5	0.34	0.14	0.28	0.29	0	0.39
MN_6	0.23	0.25	0.11	0.22	0.39	0

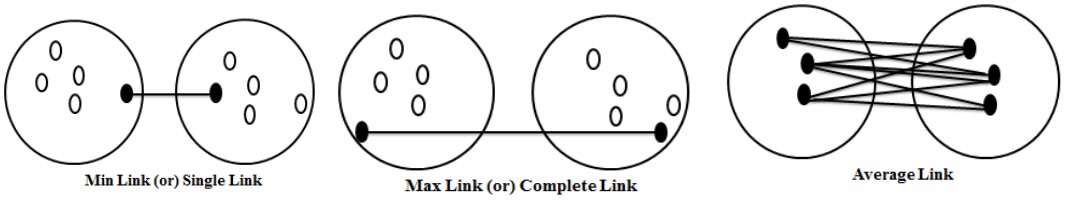

Figure 4 : Proximity Computation

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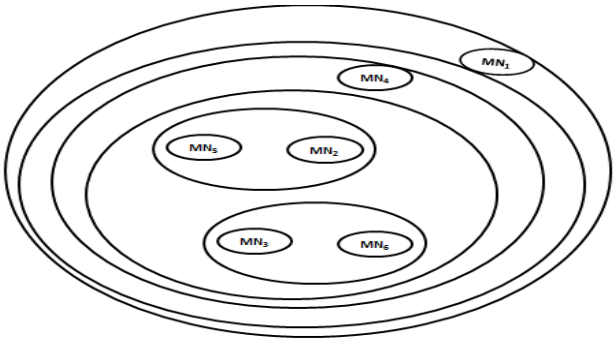

Fig 6 : Cluster Formation

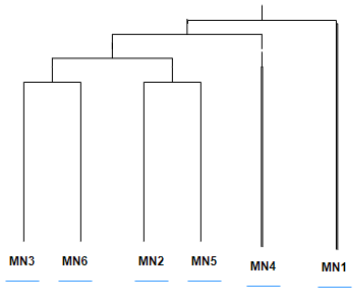

Figure 7 : Dendogram

Intra Cluster Communication

The computed proximity values are used to carry out intra-cluster communication or cluster-to-cluster communication. The cluster may be either sparse or dense, which is determined by the number of cluster member nodes. If the cluster is sparse, the two cluster nodes are connected using either min or max value proximity. A gate point node is a node that communicates with other nodes. Other nodes are interacted with through the entry point nodes. For connecting several pairs of nodes in two separate clusters in a dense cluster, average proximity is used. Each one is regarded as a point of contact for initiating communication. The NHDP protocol is used to control the connection stability between the entry points. The stable link is considered for communication otherwise alternative proximity value is taken into account to select the stable link.

Inter Cluster Communication

The Neighborhood discovery protocol[4] is used to monitor link connectivity between nodes before carrying out intra-cluster and inter-cluster communications. The “HELLO” packets are exchanged locally by the NHDP protocol within the cluster and cluster to cluster. The information about connection communication is recorded when hello packets are sent out. The one-hop method and symmetric two-hop methods are used to approximate connection connectivity. The one-hop method determines the direct relation between nodes, while the symmetric two-hop neighbor method determines the connection with its one-hop neighbor without taking the hop into account. This data is saved in the data base. The connection's quality is also saved in the link tuple. The NHDP protocol keeps track of the interface information base, which contains information about the currently lost connections. The link quality tuple is always monitored by the interface parameter, and the value of the link quality tuple is updated after the link connectivity is verified.

i) The link's quality is compared to a threshold value; if it is higher, the link is considered functional (or) stable.

ii) If the connection's quality falls below the threshold, the link becomes unusable (or) unreliable, and it is transferred to the interface parameter list.

The communication between cluster nodes and between two clusters is based on the link connectivity record. The proposed technique improves network scaling, as well as it minimize the time taken for clusters to cluster communication and the number of clusters formation.

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Results

Using the NS2.34 network simulator, the simulation of the proposed PHC-NSL technique is compared to other known algorithms such as SCBC and RPGM. A total of 500 mobile nodes are spread in a square area (1100 m * 1100 m) for simulation purposes. The node's mobility model is the Random Waypoint model, and the node's speed in the square region is varied from 0 to 20m/sec.

Table 3 : Simulation Environment

Simulation Parameters	Values
Network Simulator	NS2.34
Square area	1100 m * 1100 m
Number of mobile nodes	100,200,300,400,500
Mobility model	Random Waypoint model
Nodes speed	0 – 20 m/s
Simulation time	300sec
Routing Protocol	DSR
Number of runs	10

Discussions

Performance Evaluation

The proposed approach focuses on cluster creation and how connections are formed between nodes on both an inter-cluster and intra-cluster basis. The simulation metrics used were number of cluster from a density of nodes of 100, 200, 300, 400, and 500 nodes. The number of clusters obtained is less compared to other waiting strategies depicted in Fig.8. The delay metric is used to measure the time taken to cluster-to-cluster communication is illustrated in Fig 9.

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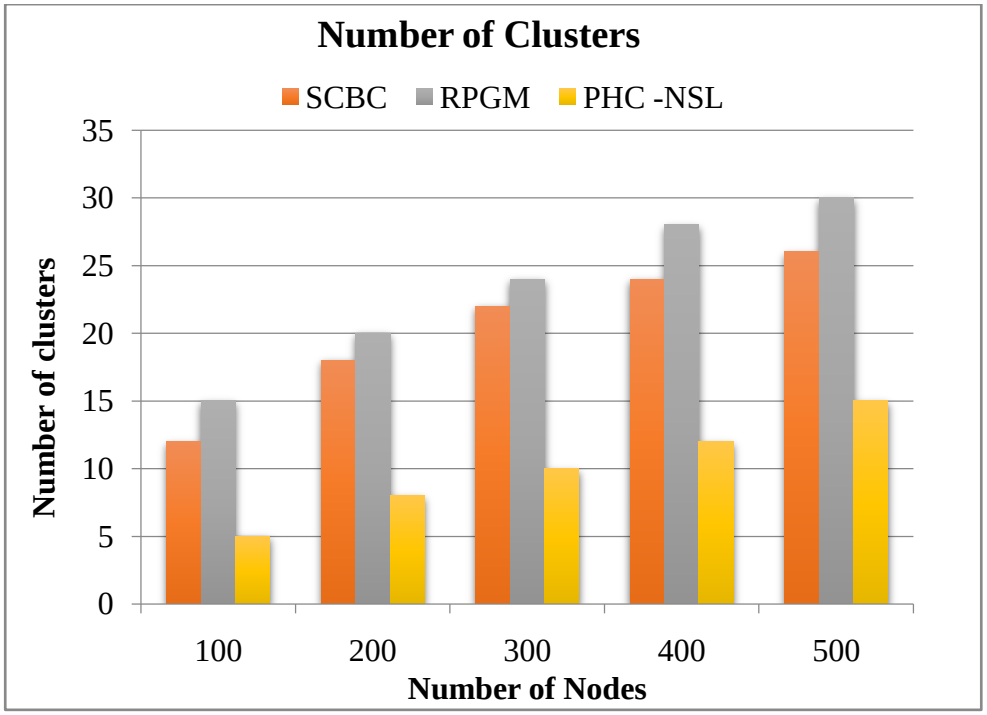

Figure : 8 Number of Cluster

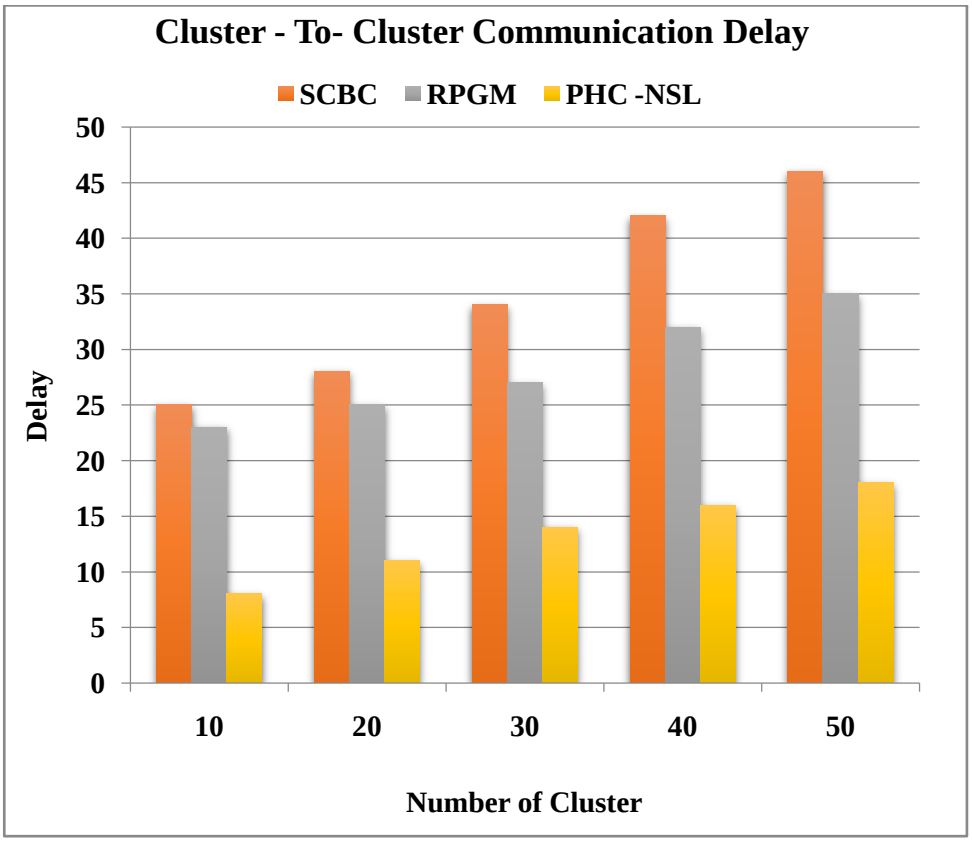

Figure 9: Cluster-To-Cluster Communication Delay

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Conclusion

The research study focuses only on the cluster formation and stable link identification between the nodes on inter cluster and intra cluster communication. The cluster formation is achieved with the help of agglomerative clustering algorithm. Using the proximity computation intra cluster nodes are communicated. Inter cluster nodes are communicated on the basis of single hop or multi hop communication. Neighbor Discovery protocol monitors the link connectivity between the nodes on inter cluster as well as intra cluster. Lose link information are stored in the interface information data base which reveal the broken link information to the neighbors. The simulation result compared with the existing methods the obtained parameters are number of cluster and delay taken to process the connection between two clusters. The number of clusters reduced compared to the other existing strategies which improves the scalability. Intra cluster connection identification time is estimated as delay that also reduced compared to other waiting strategies.

Limitations and Future Studies

Cluster formation and communication between the clusters only carried out.The future enhancement of research study will be focus on route discovery and route maintenance to provide stable communication and the parameters will be considered are routing overhead, packet delivery ratio, packet drop, collision rate and end-to-end communication delay.

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