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Systematic Analysis of Modification in Cluster Based Routing For MANET

Archana Kumari[1], Dr. Surendra Kumar Yadav[2]

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***Abstract*:** The Mobile ad-hoc network (MANET) will play a vital role in the Internet of Things in the next generation of computers. The MANET is a type of wireless network that is capable of auto-organization and self-management and connected in a system without a central command. The fifth generation, or 5G, of wireless communications is expected to deliver significantly increased data transfer speeds as well as significantly reduced end-to-end over-the-air (OTA) latency. In 5G, MANET is a radio system with the goals of having an incredibly high data rate, low latency, decreased energy consumption, and lower costs. In order to provide support for this, the routing protocols used in the MANET need to be adaptable, save energy, and achieve a high level of performance. In addition, increasing the network lifetime has only recently become a condition that must be met by any routing system designed for MANETs in order to be considered successful.In this research, we present a novel routing protocol that is high performance, energy efficient, and extends from Cluster Based Routing protocol in order to achieve the goals listed above. The most important contribution in this research is to create a modified approach that may provide high performance communication on smart devices by making use of the MANET concept in 5G. The approach of the research makes use of an accurate and effective simulation of the desired study, and it is able to be executed within a MANET framework.

Keywords*— Mobile Ad Hoc Networks (MANET), Routing Protocol, 5G Network, Cluster*

1. Introduction

Mobile Ad hoc NEtworks (MANETs) are an application of wireless networks. The term "mobile ad hoc networking environments" (MANETs) was coined and first presented in the year 2001 under the heading of "auto to-auto specially appointed portable correspondence and systems administration" applications, which allow for the framing of systems and the transfer of data among vehicles [1]. Researchers and industry professionals alike have shown a significant amount of interest in wireless networks. Access points and multiple wireless nodes are typical components of wireless networks. In recent years, the advances in wireless technology and rapid growth in personal computing devices have drawn more and more attention towards mobile ad hoc network (MANET) [2].This section presents the fundamentals of MANET and discusses the motivation and contributions of this research.

1.1 Mobile Ad hoc NETworks (MANETs)

There are two typical categories of wireless networks: infrastructure networks and mobile ad hoc networks. The most important component of an infrastructure wireless network is the base station, which provides the necessary communication to and from the mobile units in its coverage area [3]. If a communicating mobile node moves from the coverage area of one base station to another, the centralized administration maintains a seamless communication by handing over the responsibility to a new base station.The major features of above two types of wireless networks [4] may be summarized as in following Table 1.

Research Scholar,
University of Technology, Jaipur, Rajasthan, India
archanasinghjecrcphd@gmail.com

Professor,
JECRC University, Jaipur, Rajasthan, India
surendrakyadav.sky@gmail.com

Table 1: Major features of wireless networks

S. No.	Parameter	Cellular Networks	Ad hoc Networks
1	Bandwidth reservation	Easier to employ	Requires complex Medium access control protocols
2	Maintenance cost	High	Self-organization
3	Node circuitry	Less complex	More complex
4	Application Domain	Civilian and Commercial sector	Battlefield, emergency search and rescue, medical, environment monitoring etc.
5	Routing	Centralized	Distributed
6	Switching	Circuit	Packet

The characteristics of MANET as follows:

- ***Distributed operation***: The lack of fixed centralized administration to manage and control network operation makes it necessary for the designed protocols to operate in a distributed manner, requiring a high degree of collaboration between the nodes forming network [5].
- ***Dynamic Topology***: The nodes in MANETs are free to move around with time, in almost every possible manner. The unpredictable movements of the nodes, due to possibility of existing nodes leaving the network and new nodes entering in, may result in frequent disconnections. Therefore, a node reachable in current transmission does not guarantee it so in the next transmission.
- ***Dependency on battery life***: As the nodes are not fixed, they rely on batteries as their power source for efficient network operation [6]. The energy consuming operations of a node are communication and computing. Out of these communication is shown to be more energy consuming compared to computing. Communication involves transmission and receptions of data and control packets. As no actual information is being communicated in control packets, they are overhead over the data packets. Hence, reduction in communication overhead directly helps in improving the energy efficiency of the nodes. Thus mechanisms and protocols devised for MANETs need to take into account the control overhead as a major energy constraint.
- ***Peer-to-Peer nature***: The self-organizing feature of MANETs requires protocols designed for distributed environments to be peer-to-peer in nature and also to be robust enough, to handle the distributed dynamic topologies [7].

1.2 Research objective and Contribution

Routing being the challenging task and control overheads associated with 5G network clustering the major issue, study of cluster based routing protocol seems to be attractive for achieving desired scalability in dynamic networks like MANET.

The contributions of the research work may be summarized as follows:

- To proposed a modifying Cluster Based Routing Protocol (CBRP) for 5G-Mobile Ad Hoc Network. This algorithm uses a novel cluster maintenance scheme to reduce the control message exchanges for maintaining cluster structure.
- The major goals of this scheme are to achieve minimum number of cluster head to maintain stable clusters and to minimize the number of clustering overheads.
- Comparison of LCC, cluster maintenance in CBRP and proposed approach show that it consumes less control overhead in maintaining the cluster. The reduced control overheads are useful in terms of extending the node lifetime with reduction in energy consumption.

2. Cluster-Routing In MANET

Routing in networks serves two primary purposes: the first is the selection of routes for a variety of source destination pairings; the second is the delivery of data packets to the appropriate destination. MANETs have certain limitations and characteristics that prevent routing protocols designed for traditional wired networks from being directly applied to them. These limitations and characteristics include a dynamic topology, limited bandwidth, unpredictable link capacity, and energy constrained operation. In recent years, a great number of different routing protocols for MANETs have been suggested as a means of establishing and keeping track of routes. The process of routing identifies viable routes between sets of source and destination nodes, which may involve more than one node at each intermediate stop along the route [8]. Depending on the underlying communication architecture, the type of routing protocol employed can be categorized as either unicast, multicast, anycast, geocast, or broadcast. Each of the aforementioned types has a single sender, but each type also has a unique number of destination nodes that are selected in a unique way. There is only a single designated destination node when utilizing unicast routing, whereas when using anycast routing, there may be more than one possible destination, but packets are still only sent to one of those destinations. Establishing routes for the transmission of data packets to numerous destinations at the same time is what multicast routing does. These destinations are grouped together. The routing is considered to be geocast when the group is defined as the collection of all nodes that are contained inside a particular geographical region. The goal of the broadcast routing protocol is to send data packets to each and every node in the network [9].

The formation and upkeep of a well-connected cluster structure are the primary goals of the clustering process. It consists of two phases: the first phase, known as the cluster formation phase, deals with the building of clusters, and the second phase, known as the cluster maintenance phase, deals with updating the structure of clusters in accordance with the changing topology of the network. Cluster maintenance is of quite significant importance because it is related to the performance of a given clustering algorithm [10]. A cluster structure makes spatial reuse of resources; the same frequency or code set can be used by two clusters if they are not neighboring clusters and increase the system capacity [11]. Utilizing a unique mobile node can better coordinate the transmission events. This saves much resources used for retransmission due to collisions.

2.1 Classification of Clustering schemes

The classification of clustering schemes are broadly summarized and classified as follows.

- ***Cluster maintenance***: These plans seek to offer upper-layer protocols a robust cluster architecture at a low cluster maintenance cost. The structure of cluster conserved without consuming an unnecessary amount of network properties for cluster preservation by limiting the re-clustering scenarios, delaying the cluster head change, or minimizing explicit control messages for clustering [13].

- ***Graph theory*****:** These schemes tries to choose a minor amount of mobile so that the routing information and data packets are relayed only through the nodes in the dominating set only. Thus the overhead in route search or routing table preservation is compact.
- ***Energy-efficiency*****:** The energy of node in a MANET is limited hence MANET should decrease its energy depletion in order to delay in life time of the network.
- ***Cluster node degree*****:** A cluster can handle an optimal quantity of mobile nodes. A more number of mobile nodes in a cluster may overload the cluster head thus causing its battery to drain. This could lead to frequent cluster head changes resulting in multiple path breaks and hence may reduce the system throughput. When there are fewer mobile nodes in a cluster, it may be possible for there to be a greater number of clusters, which will result in an increase in the total distance travelled. Load balancing clustering makes an effort to establish higher and lesser limitations on the mobile nodes count included in each cluster. This ensures that the sizes of the clusters remain consistent. As a result, dividing the load from the network more evenly across each cluster [14].

3. Methodology

Among various routing schemes, CGSR, CBRP and Adhoc On-Demand Distance Vector, take the advantage of clustering to achieve scalability in MANETs.

3.1 Cluster Gateway Switch Routing (CGSR) Protocol

Cluster Gateway Switch Routing, also known as CGSR, is a cluster-based routing system. The mobile nodes are divided up into clusters, and a special node known as the cluster head is responsible for coordinating the activities of each cluster. The clustering technique offers a framework for the separation of codes, the accessing of channels, the routing of traffic, and the distribution of bandwidth among clusters. An algorithm for distributed voting is used to choose who will serve as cluster head. Every node that is within the transmission range of the cluster head is considered to be a member of that cluster and is referred to as a cluster member. Through the use of gateway nodes, communication can take place between two different clusters. A node that is inside the range of transmission of two or more cluster heads is referred to as a gateway node. Because of the consistent shift in the cluster head, a significant amount of time will be spent converging to the new equilibrium state. A method known as least cluster change (LCC) is utilized in order to get around this overhead. A change in the cluster head position will only take place, in accordance with the LCC algorithm, when two cluster heads come into touch with one another or when a node moves out of range of all other cluster heads. CGSR is an extension of DSDV that improves traffic routing by employing a cluster or hierarchical routing strategy to direct traffic from its origin to its final destination. According to the cluster routing strategy, a packet is first sent to the sender's cluster head, after which it is sent to the gateway, and then it is sent on to the next cluster head. This process repeats itself until the packet reaches its destination. This procedure is repeated until the cluster head of the destination node is not found to have been reached [15].

3.2 Cluster Based Routing Protocol (CBRP)

CBRP divides the nodes of a mobile ad hoc network into clusters with a diameter of two hops. These clusters can overlap with one another or be completely separate from one another. Each cluster that is aware of the addresses of all of its member's votes to determine which node will serve as the cluster head for that cluster [16]. This node is responsible for the routing process. Gateway nodes are the conduits through which communication occurs between cluster heads. When the clusters overlap, a node is considered to be a gateway if it has two or more cluster heads as its neighbors; when the clusters are disjoint, a gateway node must have at least one cluster head and another gateway node as neighbors. A node can be in any one of these three states at any one time: a fellow of a cluster, the head of a cluster, or undecided. Every node in the network regularly sends out a "hello" message to the nodes that are immediately adjacent to it.

Each node has its own neighbor table, which it uses to store data of its neighbor nodes and the direction of the link to that node. This is done so that the cluster formation process can be supported by the individual nodes. The neighbor table is kept up to date by regularly broadcasting "hello" messages to all of the neighbors. The state of a node, its neighbor table, and its cluster adjacency table are all described in the information that is included in a hello message.

The routing method in CBRP makes use of a cluster adjacency table as well as a two-hop topology database. The cluster adjacency table is where information about neighboring clusters is stored. The cluster adjacency table provides access to this information for those who are interested. The database that is used to depict the topology of a two-hop network is compiled with the assistance of the information that is collected from hello messages. It comprises all of the nodes that are within a maximum of two hops of the current node in question.

3.3 Adhoc On-Demand Distance Vector (AODV)

This protocol provides both unicast and multicast routing, and it may build routes to destinations based on the user's specific requests. The AODV protocol will only build routes between nodes in the network in the event that the source nodes make a request for the routes to be built. As a consequence of this, AODV is understood to be an on-demand algorithm, and it does not produce any additional traffic for communication along networks. The routes will continue to be maintained for as long as the sources have a need for them. They also create trees in order to connect the members of multicast groups. The usage of sequence numbers is one of the ways in which AODV ensures that routes remain current. In addition to scalability to a large number of mobile nodes, they are self-starting and free of feedback loops [17].

The networks used in AODV remain dormant until connections are made between them. Nodes in the network that are in need of connections will send out a request for a connection. The message is then forwarded by the remaining AODV nodes, which also record the node that initiated the connection request.

As a result, they establish a number of temporary routes leading back to the node that sent the request.

3.4 Least cluster head change (LCC)

The formation of the clusters is accomplished through the application of two straightforward criteria [18]: one is established on the node ID, and second is constructed with the node degree. To be more specific, the nodes with the lowest ID and the nodes with the highest degree are chosen to be the cluster heads in the process of cluster data.

The role of cluster head is given to the node that, relative to its neighbors, has the lowest ID. When a cluster head discovers a member with an ID that is lower than its own ID, the cluster head is compelled to relinquish its function as cluster head to the node that has the ID that is lowest. When using HCC, the clustering process is carried out on a regular basis so that a cluster head's "local highest node degree" can be verified. When a cluster head discovers a member node that has a greater degree than it has, it is compelled to give up its status as the cluster head. Because of the mobile nature of the nodes, re-clustering occurs frequently in both the LIC and the HCC mechanisms. An enhancement is suggested in LCC in order to prevent the occurrence of such frequent re-clustering.

The process of clustering is broken up into two parts in LCC: the first step is called cluster formation, and the second step is called cluster maintenance. The LIC is simply followed throughout the establishment of the cluster. This means that initially, the mobile nodes in the area that have the lowest ID are selected as the cluster heads [19].

The constraint that a cluster head should always have certain precise properties in its immediate vicinity is loosened up thanks to the LCC, which results in a major improvement in the cluster's overall stability. However, the next instance of re-clustering in LCC shows that the transfer of a single node can still cause the re-computation of the entire cluster structure; once this occurs, it is impossible to avoid the substantial increase in the communication cost associated with clustering. And the cluster head change is implemented whenever two cluster heads come within radio range of each other, which can happen at any time.

4. Proposed Scheme

Because each cluster in CBRP is distinguished by its own cluster head, it is in everyone's best interest to keep the number of cluster head shifts to a minimum whenever possible. CBRP mandates the following cluster head change rules in order to ensure the proper functioning of the cluster. However, these systems might force an unwanted shift in the cluster heads when two cluster heads are only passing each other. In order to forestall this unwelcome change in cluster head configuration, the alter cluster Maintenance Scheme has been proposed.

Some used notations in the algorithm as follows:

- Node ID: The Node ID is a string that identifies a specific mobile node in a way that is not shared with any other nodes. The node IDs have to be in a completely logical order.
- Cluster: A collection of nodes is known as a cluster, and among those nodes, one is chosen to serve as the head of cluster. The Cluster Head ID is used to uniquely identify a cluster. The relationships between clusters might either be overlapping or disjunctive. Every node in the network is aware of the Cluster Head(s) that correspond to it, and as a result, it is aware of the cluster(s) to which it belongs.
- Cluster Head: During the process of making a cluster, each cluster picks a leader. Each group of things should have one and only one group head. Every node in the cluster is connected to the cluster head in both directions. Once the topology within a cluster stabilizes, a cluster head will know everything there is to know about group membership and link state within a certain amount of time.
- Cluster Member: Members of a cluster are all the nodes in the cluster other than the cluster head.
- Gateway Node: A gateway node is any node that a cluster leader can use to initiate communication with another cluster.
- HELLO message: A node's Neighbor Table is included in its HELLO message, which is broadcast periodically at intervals of HELLO INTERVAL seconds. In some cases, a node may send out a triggered HELLO message when an urgent situation arises.
- Neighbor table: Every node creates and updates a neighbor table to record data about its immediate neighbors in order to facilitate the clustering process. It's where we keep track of things like nodeID, neighbor node roles, and link status.

The proposed method has a mechanism for the construction of clusters that is established on the bottommost ID clustering. In this algorithm, the node in a neighborhood that has the lowest ID is chosen to be the cluster head. Node ID uniquely identifies a given mobile node. The node IDs have to be in a completely logical order. Periodically control messages, termed as *hello* messages, are broadcast by each node, to maintain update information in neighbor table. The time gap between transmissions of two consecutive *hello* messages is called *hello*_interval. In CBRP, when two cluster head come in each other's range and remain so for CONTENTION_PERIOD, node with higher ID leaves the cluster head role. Instead of allowing the cluster heads to take autonomous decision about their role at CONTENTION_PERIOD, the decision is proposed to be further delayed to avoid unnecessary change from taking place in situations of two cluster heads just passing by.

When two cluster heads come within range of each other, the cluster head change will be delayed for delay period, which will initially be equal to hello interval. This is the strategy that has been recommended, the hello interval value that is used to determine the delay period value is increased if, at the conclusion of the delay period, both cluster heads are once again within the range of each other. The delay period is prolonged by an amount equal to the hello interval each time both cluster heads come within range of one another. This process will continue until the delay period is lower than or equal to the maximum limit, which may be determined by dividing the transmission range by the speed and then adding two to the resulting value. If they are both still within the range, the one with the smaller ID will continue to function as a cluster head, while the other will relinquish its responsibility to function as a cluster head.

5. Results And Discussion

The LCC, CBRP, and the proposed approach have all been incorporated into the NS-2 system. The simulations are broken up into two distinct parts. In the first stage of the process, simulations are run by varying the mobility, and in the next phase, simulations are run by altering the node density. For simulation parameters we used 150 number of mobile node, total 2000x500m simulation area for 300 second time and the transmission range for mobile nodes was 250. We record the number of cluster head and cluster member alterations and clustering overhead when the pause time is adjusted in 60-second increments from 0 to 300 seconds. The performance metric is measured while the node speed is adjusted between 5 and 25 meters per second in increments of 5 meters per second so that the influence of speed may be observed.

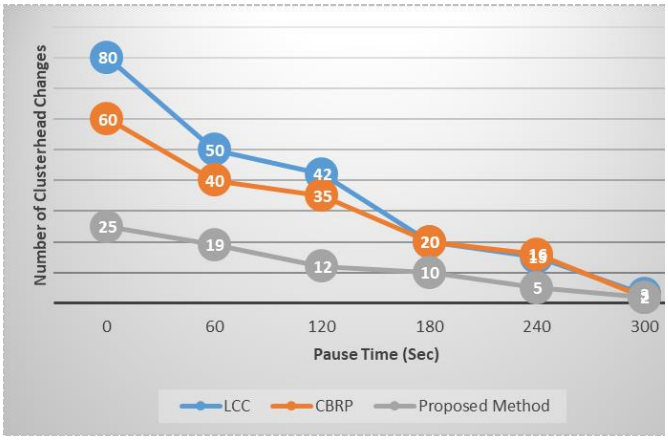

Fig. 1: Number of cluster head change vs. pause time

Figure 1 illustrates the relationship between the amount of pause time and the number of cluster head changes. In LCC, CBRP, and the technique that was proposed, the needed number of cluster head changes decreases to a very small number as the stop period grows. It is evident from the figure that the proposed method performs significantly better than both LCC and CBRP. The suggested method requires roughly one third less cluster head changes than LCC does at the greatest mobility level, when the nodes are continuously moving; in contrast, CBRP requires approximately twice as many cluster head changes. The CBRP method performs marginally better than the LCC up to a stop time of 180 seconds, after which both schemes perform equally, however the proposed technique performs significantly better than either of them. The delay strategy change by the cluster head that is utilized in CBRP and the proposed approach are the root causes of this distinction in performance. In CBRP, the delay is always equal to the CONTENTION PERIOD, but in the suggested technique, it is a task of both the transmission range and the speed of the signal.

The changes in the number of cluster members are depicted in Figure 2 as a function of the amount of pause time. As the pause duration increases in LCC, CBRP, and the technique that is being presented, the required number of cluster member changes drops to an extremely low level. It is obvious from fig 2 that the proposed technique outperforms both LCC and CBRP in terms of performance. The number of cluster member changes required by the suggested approach is around 1/9 of that of LCC and one fourth of that of CBRP when the level of mobility is at its peak and the nodes are continuously migrating. For pause times up to 180 seconds, the CBRP method works better than the LCC. After that point, both schemes perform equally, but the proposed approach implements better than either of the others. This shift in behavior is rationalizable in terms of the number of cluster head adjustments that are necessary in the respective schemes. In comparison to the LCC and CBRP schemes, the suggested method has a lower total number of re-affiliations, which is indicated by the lower number of cluster head modifications.

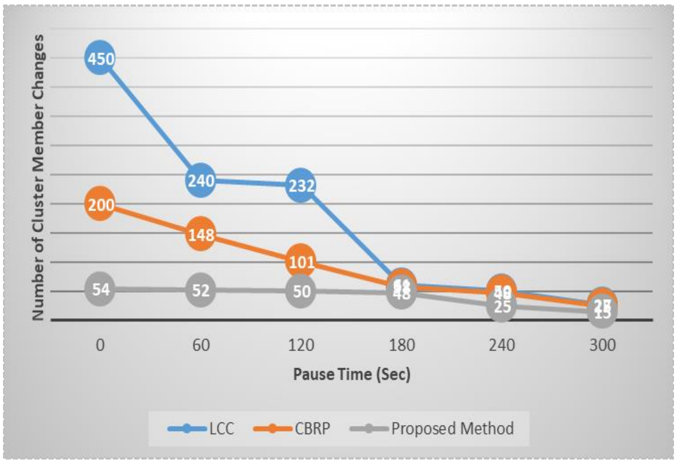

Fig. 2: Number of cluster member change vs. pause time

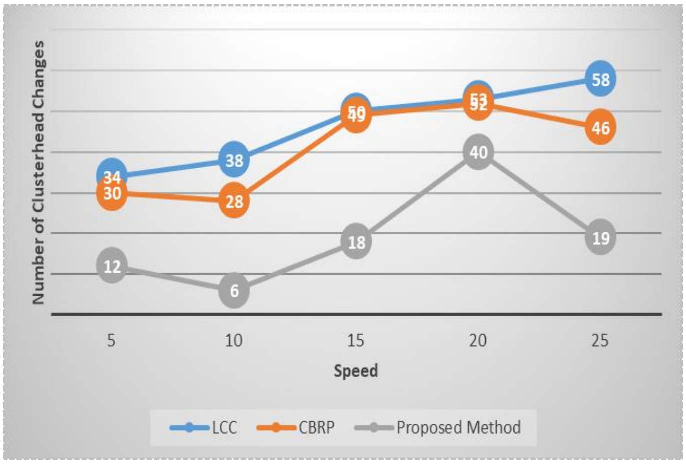

Fig. 3: Number of cluster head change vs. speed

Figure 3 illustrates the relationship between the different speeds and the variations in the cluster heads. Cluster heads increase with speed that take place occurs more frequently in all three of these approaches: LCC, CBRP, and the suggested method. In comparison to both LCC and CBRP, cluster head count changes that occur in the suggested technique at any speed between 5 and 25 meters per second is significantly lower. It's possible that simulation limits are to blame for the rapid uptick in the frequency of cluster head changes at 20 meters per second.

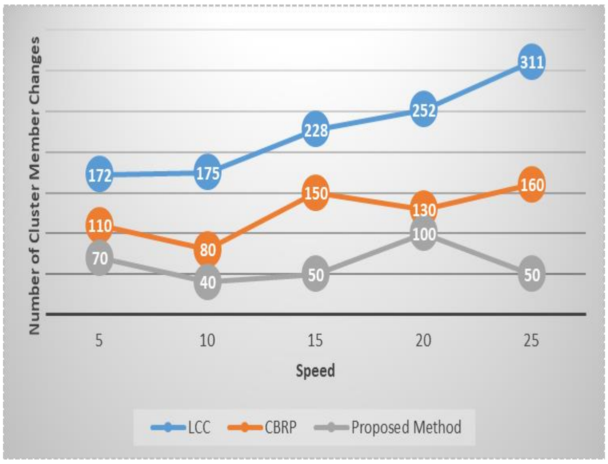

Fig. 4: Number of cluster member change vs. speed

Figure 4 depicts the variation in the modifications made by cluster members in relation to the variation in speed. With growth in speed, the number of cluster member changes occurs more frequently in all three of these strategies: LCC, CBRP, and the proposed technique. The proposed method has a lower total number of cluster head replacements, which results in a lower total number of cluster member reaffiliations. As a result, the total number of cluster member changes needed by the proposed method is significantly lower than those needed by the LCC and CBRP methods.

6. Conclusion

A clustering maintenance method was devised and then examined as part of this research. This is because the performance of protocols like scheduling, routing, and signaling is impacted when the constancy of the cluster in a MANET is compromised. In order to prevent an unwanted cluster head change from occurring, the fundamental concept behind this technique is to put off changing cluster heads while 2 cluster heads are within the transmission range of each other. The experiment result of proposed method shows the improvement in the cluster maintained process in comparison to LCC and CBRP. This applies to cluster head, member, and clustering overhead modifications.The CBRP strategy for delay change in and the proposed approach are the root causes of this distinction in performance. In CBRP, the delay is always equal to the CONTENTION PERIOD, but in the suggested technique, it is a function of both the transmission range and the speed of the signal. In comparison to the LCC and CBRP schemes, the suggested method has a lower total number of re-affiliations, which is indicated by the lower number of cluster head modifications. When compared to LCC and CBRP, the clustering overhead that is necessary for the suggested technique is significantly lower. In the technique that has been presented, a lower total count of cluster head changes will result in a lower total number of cluster member reaffiliations, where does control overhead often come from. Therefore, the goal of the proposed approach, which was to provide a steady configuration for MANETs, is successfully achieved.

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