AN IMPROVED MAINTENANCE ALGORITHM FOR MANET

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***ABSTRACT** : Clustering in Mobile Ad Hoc Network (MANET) is used to reduce connection load and eliminate network routing traffic. The MANET features led to many difficulties in partitioning the networks into clusters, such as Cluster Head (CH) selection and choosing an appropriate route for sending and receiving data. This research aimed at enhancing the performance of clustering in MANET, based on Enhanced Cluster Routing Protocol maintenance algorithm which has been developed based on error virtualization which is Link failures, node movement, cluster head movement, two CHs with the same scale, and node shutdown. The findings show that the proposed algorithm is more stable and effective than the existing algorithms, as shown in the final trust scores in terms of throughput, the packet delivery ratio, end-to-end delay. Hence, the findings indicate that the proposed algorithm can achieve 10% stability improvement, compared to other cluster-based algorithms. The cluster maintenance algorithm in MANET contributes to enhance the network stability, minimize the maintenance burden, and reduce the number of packet loss.*

Keywords: cluster, maintenance algorithm, routing algorithm, MANET.

1. INTRODUCTION

Recently, the utilization of communication equipment that is personal, such as laptops, cellular phones, and personal digital devices, has grown significantly. This growth was accelerated by the reduction in the price of these devices, supported by wireless interfaces. These wireless interfaces enable them to be connected to base stations available at different locations, such as railway stations, airports, hospitals, and universities. These small, portable devices are simultaneously able to connect directly with each other without the need for any base station. Hence, a Mobile Ad Hoc Network (MANET) is created However, the connectivity between nodes in MANET is hampered by the movement of nodes, new node additions to the wireless network, and the node being shut down. This has created a critical need for a self-regulated network capable of being resolved under modifying connection without the main management. Additionally, the unlimited mobility of MANET hops makes them produce many ways. Consequently, precise paths with lower traffic can be established for these nodes. Towards this end, clustering has proved beneficial in reducing the complications of flat routing, since clustering significantly reduces the occurrence of the routing traffic through the flat routing process. Clusters partition MANET into small node groups; each group (cluster) comprising a cluster head node (CH), gateway, and normal (ordinary) nodes. Hence, the cluster head node is allowed to make routing decisions for a small number of hops, which in turn efficiently utilizes the available resources. Conceptually, dividing the dynamic wireless network into a number of clusters (groups) was first suggested by several researchers who developed a self-organized, distributed algorithm to determine and maintain a linked structure despite the hop mobility and failure of hops.

The efficiency of packet delivery is viewed as a significant goal of all MANET routing protocols and is highly significant in different kinds of application in wireless networks, for example, intelligent agriculture monitoring systems, security management, and intelligent industrial sensor systems. It is possible to enhance these applications in wireless network systems by utilizing a communication model that is mobile, self-organized and offers a MANET approach. In this type of network, each node is deemed to be less costly and has adequate battery life in all possible communications. MANET comprises several mobile nodes with no distinction between a node that is normal and a router because all nodes could be utilized for sending, receiving and forwarding packets [1,2,3].

Due to the mobility of the MANET nodes and the changes in network topology, the routing in this network is more complicated than in other networks. However, the traditional flat topology design is not efficient for networks with a great number of nodes since the control messages need to be transferred into hops of the network. Therefore, to solve the problem of packet pathing, different approaches according to the hierarchical topology design for MANET are suggested.

In the hierarchical topology design, there is a division of the network into several clusters, each cluster comprising several nodes [4]. Therefore, the control messages only pass through a specific cluster, which reduces the bandwidth overhead and the storage requirements for the network with a great number of nodes. Hence, clustering can be used to support large network scalability.

An appropriate routing method plays a significant role in the achievement of MANET because of its dynamic nature, which results in increasing the control overhead and bandwidth consumption in this type of network. The current MANET routing protocols can be classified into three groups: on-demand, table-driven, and hybrid. In the table-driven protocol, all nodes are needed to preserve routing tables by sending periodic updates to check modifications in the network structure. A route is always available. This type of routing needs continuous updates, leading to the consumption of more network resources. Moreover, many of these routes may never be utilized due to topology changes and high node mobility. Therefore, this type of routing protocol is more appropriate for small-sized networks with minimum mobility.

There are several advantages when clustering in MANET is compared to traditional networks because the former permits the best performance regarding the protocol by enhancing throughput, network delay, scalability and power usage. Additionally, it facilitates the enhancement of network layer routing by minimizing the routing tables' size. It also reduces transmission overheads by updating the routing tables when topological changes take place, and facilitating the aggregate topology information as the size of a cluster is smaller than the size of the whole network. Hence, each node retains only a part (fraction) of the total amount of network routing information.

Despite these advantages, clustering still has many limitations, because the dynamic nature of MANETs hampers the cluster-based routing protocol from dividing a whole network into clusters and specifying the CH for each cluster. Additionally, clustering decreases connection and control overheads because of the pre-specified paths of communication through cluster heads. This is crucial for scalability of media access as well as routing protocols. Moreover, many mobile terminals (s) are regulated by a MANET utilizing a cluster topology. Forming and maintaining a cluster structure incurs extra cost in comparison with topology control without a cluster [5][6]. Consequently, clustering has a number of side effects and disadvantages, which are summarized as maintenance problems. The rapid changes in wireless network topology involve a variety of mobile hops, resulting in an increase in the number of information messages exchanged until a critical point is reached. This information exchange consumes much network bandwidth and energy in mobile nodes [7]

Another limitation in clustering is the ripple effect of re-clustering that takes place if any internal events occur, such as the mobility or expiring of a mobile node. This may cause the re-election of a new cluster head, resulting in re-elections throughout the entire cluster structure and affecting the performance of higher-layer protocols through the multiplier impact of re-clustering [8]. Another serious disadvantage of clustering in MANETs is the high power consumption of some nodes in comparison with other nodes within the same cluster [9]. This is because a special node, like a gateway or a cluster head, is involved in managing and forwarding all the messages of the local cluster, which implies relatively high power consumption in comparison with ordinary nodes. The ultimate possibility is that nodes are shut down (Zhou *et al*., 2009; Gupta *et al.*, 2014).

As shown in Figure.1 MANET was built using the proposed ECRP to form the cluster; maintain it by recovering from errors, depending on the type of topology changes; then establishing routing with least movement and minimum distance.

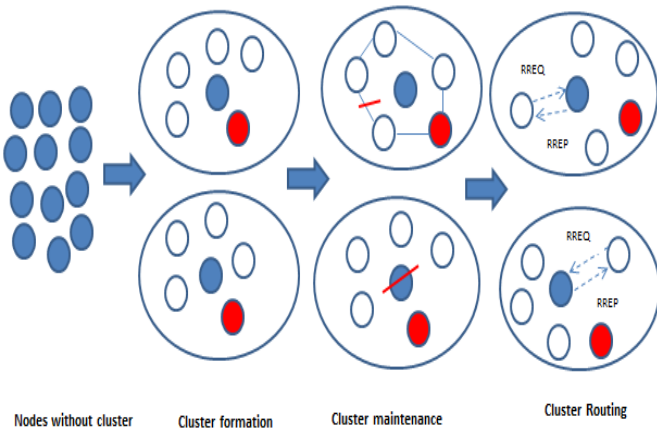

Fig. 1 Cluster Mobile Ad Hoc Network

2. RESEARCH MOTIVATION

The rapid increase of smaller and cheaper devices like mobile phones, PDAs and laptops and the growing need to exchange data between people within a short transmission range has led to the development of MANETs. The most important role of any network system is to transfer data from the source node to the destination efficiently and immediately. MANETs have many characteristic features, such as their dynamic nature, limited storage capacity, and restricted battery power. These features imply certain limitations on discovering and maintaining the routes of such a packet delivery and make the process of routing and resource management difficult [10]. In this regard, numerous architectures have been proposed to perform this task, which may broadly be categorized into flat architecture and hierarchical architecture, depending on the node topology arrangement [11]. In flat architecture, scalability is not sufficient to verify the expected aims of allowing the new nodes to enter and join the network and current nodes to leave the network. Regarding flat topology, the scalability worsens when the size of the network increases [12]

On the other hand, in the hierarchical type, all the specifications and details of the nodes are kept by groups of nodes in sets (clusters). Consequently, all the management and control packets have to be transferred within a specific number of nodes in the same cluster. Thus, the hierarchical structure can be used to minimize the bandwidth overhead and storage by using clustering, which is considered sufficiently scalable and efficient to overcome the problems of flat topology [13]. The main purpose of clustering is to construct and maintain a specific cluster topology. It is divided into two stages: the cluster formation (construction) and the cluster maintenance. The former is used to build the main cluster structure and select the head of each cluster. The latter is used to maintain and update the cluster topology according to the network topology changes [14].

Routing traffic between clusters is performed using a cluster head, which manages and keeps the routing information. This routing information results in reducing routing traffic which occurs during the routing process to provide an efficient clustering algorithm; it also makes the cluster structure as stable as possible in order to minimize resource utilization and enhance routing performance[15].

Several studies have been conducted to obtain either a maximum cluster stability or a minimum dominant set in order to reduce the number of re-elections and re-affiliations by the mobile nodes. The principle of partitioning the nodes and routing packets differs in various algorithms by emphasizing different node parameters, such as mobility, connectivity, identification, remaining battery power, and sometimes a combination of multiple parameters. However, the re-election of the cluster head is considered a major challenge in MANET and has been studied in several algorithms. This provides a motivation for designing a scale-based clustering algorithm that can increase cluster stability as well as reduce the maintenance overhead. Hence, the routing performance is improved.

The main goal of this research is to improve the performance of the cluster routing protocol by suggesting an effective maintenance scheme has been used to improve the quality of the cluster routing protocol.

2. MOBILE AD HOC NETWORK CLUSTERING

Wireless MANET comprises lots of nodes that work as routers. A MANET can be created dynamically with no infrastructure, although the clustering method considerably minimizes routing overheads and traffic (Jason *et al*., 2009). The clustering approach in a MANET divides the entire network into small groups of nodes; each group comprises a head of set, gateway hops, and ordinary nodes. This operation can also be employed in the optimal use of available facilities in large networks. Figure.1 represents all the hops linked in the MANET system with no sets involved, and Figure 2 network using sets.

Fig2: MANET without sets

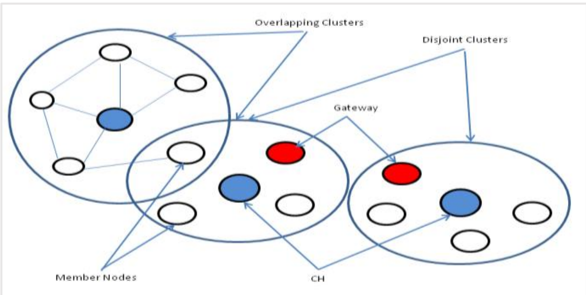

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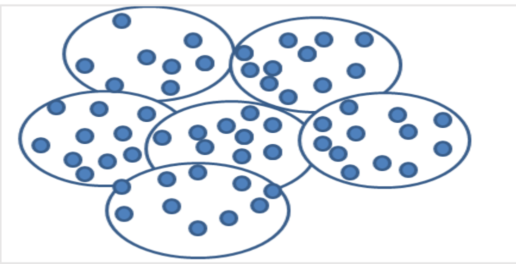
Fig.3: MANET using se

In MANET, the clusters are primarily categorized into overlapping and disjoint clusters [16]. as illustrated in Figure 3. The main circle represents a cluster, and the dots in the cluster is the hops of the wireless network. vertices connecting the small dots stand for connections between the nodes.

Fig 4: Overlapping and disjoint clusters



When the clusters are built, as indicated in Figure 4, the main node of each group is named the cluster head (CH); it manages the resources for all the hops in its group by finding an appropriate route to any hop in an identical cluster and allocating the inter- and intra-communication process. In the process of intra-interaction, each node may be connected to the others, so the data can be moved directly. The gateway node serves as an intermediary node for any interaction outside that group, which implies linking with other clusters.

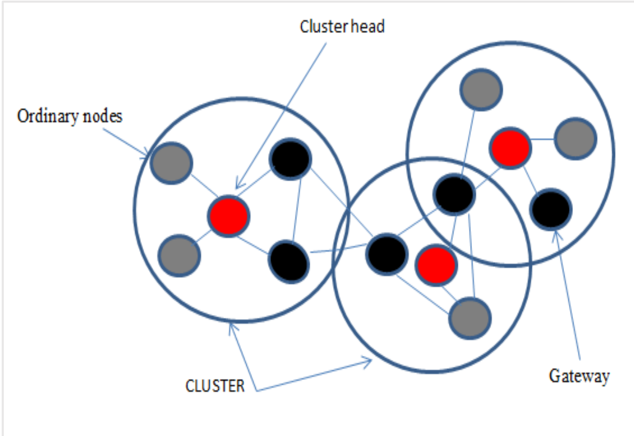


Fig.5: MANET sets

The decision to select the CH depends on the specific algorithm. Any group must certainly be confirmed, utilizing the following properties to meet the requirements of MANET:

-Any node that is ordinary should be a neighbor to at least one CH.

-Any node that is ordinary should be a neighbor to the CH with the larger weight.

- CHs should not be neighbors to each other [17].

4. PROPOSED MAINTENANCE ALGORITHM

The maintenance of a set is used to make the safe receiving of data packets when MANET networks are used The maintenance can be abstracted into the following features: Link failures and hops shutdown). The details of these visualizations are described below.

A- Failure of the Link

In the suggested algorithm, failure can be distinguished into two kinds. As represented in Figure 5,6. The first one affects the topology of the sets. When two hos *L* and *O* are related to one set and send a data for telling the set head when the connection among them is broke. The set head then modifies its connection appendix. If the 2 hops are available its management, it asks those hos to change their connection appendix data. If the hops are out of its management, the set head requests them to make another set. The hop with the highest value will be used as a set head. The 2nd one of connection failure is not effects the set topology among 2 sets. As represented in Fig.5, the two hops tell the set head related to failure using a data.

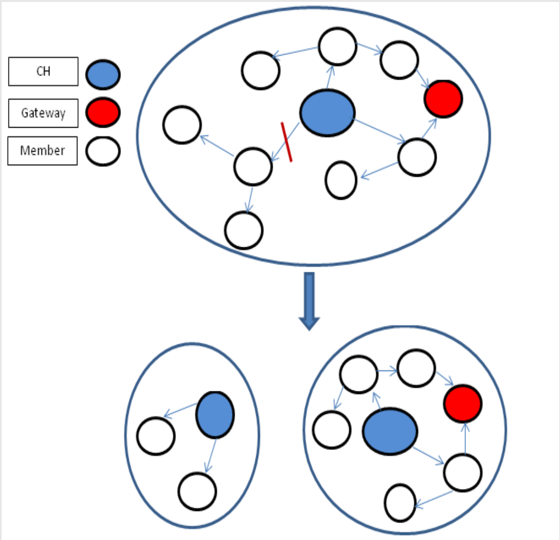


Fig. 6: Link failure within the same cluster

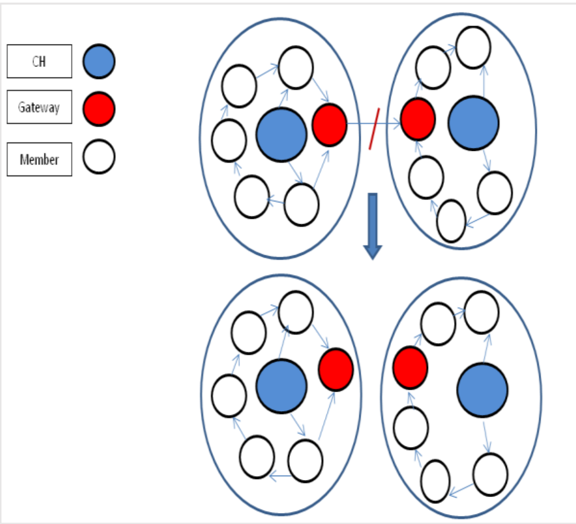


Fig.7: Link failure between cluster1 and cluster 2

B- Node movement

In the ECRP algorithm, as shown in algorithm 1, when a node change position from 1st set to 2nd set, it sends a data to the hops in the new set. This message contains important information regarding the node, including its ID, message type, location, and scale. The current set head calculates the permitted number of nodes. If the set does not have the greatest number of hops, then the set head sends a positive message to the new hop. The new hop responds with an appended data to announce its value into the new set. The main differences between this algorithm and the weighting clustering algorithm are that if a node with low mobility and high score moves and joins another cluster, this node will be directly selected to be the CH of the cluster without a need to re-calculate the CH value, but it only checks the APOW. If its power is greater than the maximum power threshold, it declares itself as a set head. Another difference is that if an ordinary hop moves to another cluster, there is no need for re-clustering in the original cluster, but it needs to update the neighbor table for the cluster members. However, this is in contrast to the traditional cluster algorithm that needs to re-cluster all the clusters, not only cluster changes. This reduces the time and control overhead of the network. Algorithm 1 illustrates the procedures of the proposed criteria.

(1) *Begin*
(2) *{*
(3) *The node that needs to join the cluster sends Join request to the CH.*
(4) *The CH will check the number of the available nodes in its cluster {*
(5) *If (available members in cluster <maximum permitted number of nodes){*
(6) *Cluster head will accept the node request.*
(7) *Update the member table.*
(8) *Broadcast the new updated member table.*
(9) *Else*
(10) *{*
(11) *Cluster head will reject the (Join) request.*
(12) *The node that sent the request will search for another cluster.*
(13) *}*
(14) *End*

Algorithm 1: The procedure of node movement algorithm

5.RESULTS

The performance of the maintenance algorithm was assessed with a pair of dissimilar sections to examine the effect of speed and number of a node on the performance of the suggested routing protocol. A comparison was made of the outcomes of proposed one with maintenance and the Incremental Maintenance Clustering Scheme (IMS) and Improved Maintenance Strategy (ICMS). IMS algorithm was proposed by [4] which depended on the smallest ID clustering algorithm, where the node with the minimum sequence number was chosen to be the CH of a cluster. IMS is used for the maintenance of two CHs within the same transmission range. The second algorithm was the Improved Cluster Maintenance Scheme (ICMS) proposed in [6]. ICMS calculates the scale of each node depending on node degree and bandwidth consumption. ICMS shows a higher performance than other algorithms, but it is limited in the number of nodes which can be covered by the cluster. Therefore, it is used for the small-sized networks in order to minimize the number of candidate's nodes which need to be the set head. The functioning of these algorithms was computed using throughput, end-to-end delay.

Throughput

As represented in Table1 and Fig.6, at the start of the simulation, the threshold for all methods was greater than 300 Kbps. The difference between them is small until the node speed is more than 8 m/sec. The throughputs of the proposed routing protocol, IMS and ICMS maintenance decrease as the node speed increases. The throughput of ECRP maintenance is higher than that in the other algorithms. When node speed is slow, the improvements obtained from using this algorithm are 10 to 42 Kbps, and this value increases to 40 to 71 Kbps as nodes become faster.

Error handling algorithms utilized in the event of various hop failures can raise received data in a period unit mainly because in proposed maintenance algorithm when any node joins or leaves the cluster, the CH will directly notify and send an update message to all cluster members in order to update the member table. In IMS and ICMS, when there are two clusters in the same transmission range, a new member table needs to be built after any re-clustering process.

Table 1: Throughputs for a proposed routing protocol, IMS and ICMS maintenance algorithms versus speed

Speed (m/sec)	IMS	ICMS	proposed routing protocol
2	350.12	355.62	365.23
5	310.23	325.62	342.32
8	280.18	298.62	328.23
10	240.21	274.44	311.22
14	220.12	260.89	289.21

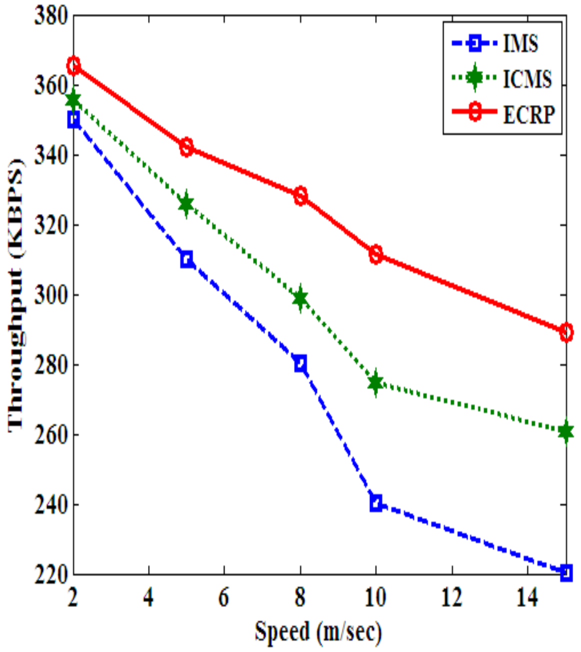


Fig.8: Throughputs for the proposed routing protocol, IMS and ICMS maintenance algorithms versus speed

End-to-end delay

As shown in Table 2 and Figure 9, in all maintenance algorithms, end-to-end delay increases as node speed increases. The ECRP maintenance algorithm has lower end-to-end delay compared to the IMS and ICMS maintenance algorithms. The enhancements in end-to-end delay between them range from 0.009 to 0.020 sec. The IMS and ICMS algorithms depend on the delay time (which is represented by the 'hello' interval time) and this value increases incrementally until the ties between the two cluster heads is resolved. Then it will start the CH re-selection, which wastes time. In proposed maintenance, if there are two cluster heads with the same scale, CH1 will check its member table. If there is more than one gateway, the node will change to an ordinary node; otherwise, it will check its scale. If its value is more than the current gateway, it will declare itself as the gateway of the cluster, and if the CH shuts downs or moves, this gateway will be used as the CH to reduce re-clustering operations.

Table 2: End-to-end delay for proposed algorithm, IMS, and ICMS maintenance algorithms versus speed

Speed (m/sec)	IMS	ICMS	ECRP
2	120.33	115.66	111.25
5	130.25	125.63	117.32
8	135.24	129.32	121.88
10	145.25	131.32	128.88
14	151.23	136.21	131.79

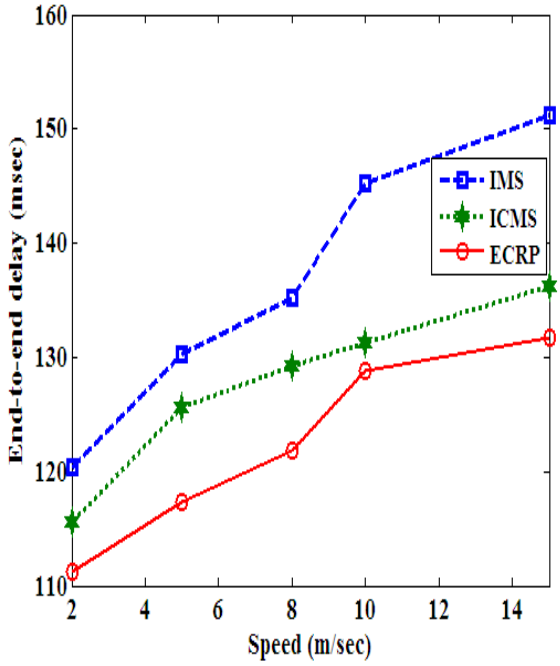


Fig 9: End-to-end delay for proposed algorithm, IMS and ICMS maintenance algorithms versus speed

6. CONCLUSIONS

The paper suggested cluster maintenance algorithm, and analyses the suggested maintenance algorithm to investigate its effect on the functioning of clustering in MANET. The proposed maintenance stage uses certain criteria to identify faults in the MANET and recovers them based on their kind. The simulation outcomes confirm that this algorithm can enhance throughput, which implies that the error recovering algorithms employed in a case of various kinds of hop failures can increase the rate of delivered data in a period unit, thus improving route performance. Another reason for this increment is that when any node needs to join or leave the cluster, the CH will send an update message to all cluster members in order to update the member table without a re-clustering process. The obtained results also show that ECRP maintenance has a low end-to-end delay. By using special criteria to recover each error according to its type, the number of CH changes and member changes was also decreased because it selects nodes with high scales to be the CH, which reduces the number of CH changes. This minimum value is reflected positively in proposed cluster maintenance performance. This algorithm reduces clustering overhead because it has a distributed transmission through the three cluster stages.

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