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An Efficient Position and Distance Based Clustering Approach in Mobile Ad Hoc Network

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Abstract: *MANETs are autonomous systems consisting of mobile hosts that are connected by multi-hop wireless links. They are formed by a group of nodes that can transmit, receive and relay data among themselves. Since Mobile Ad hoc network does not require any fixed infrastructure. MANETs raise new challenges when they are used in large scale network that contain a large number of nodes. Due to this challenging approach, the mobile nodes can form groups called clusters for their stability and for providing better communication among the network. Each cluster contains a particular node called Cluster-Head, which is elected according to a specific metric or a combination of metrics such as mobility, weight, distance, identity, energy and degree. Many clustering algorithms have been proposed to choose Cluster-Head based on these factors. These algorithms may lead to low connectivity and high delay in the network. Hence, this paper proposed position and distance based clustering approach for offering better connectivity among the network. The proposed clustering algorithm first form the clusters based on the position of the nodes then it will select the Cluster-Head based on the distance of the nodes. The performance analysis of the proposed position and distance based clustering approach is carried out using NS-2. The performance is analyzed by using the metrics packet delivery ratio, dropped packets and end-to-end delay.*

Keywords*: Manet, clustering, cluster-head selection, position and distance based algorithm.*

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I. Introduction

Mobile Ad hoc Network (MANET) is an autonomous network which contains mobile nodes and it communicates with each other through radio waves. The features of MANET such as self-configuring, self healing, self organization, self addressing and infrastructure-less architecture extensively attracts the internet applications. Each device in MANET is free to move independently in any direction and will therefore change its links to other devices frequently. The mobile nodes that are in the range can directly communicate with each other through their interfaces. These networks are fully distributed and can work at any place without the help of any fixed points or base station [1].

Mobile Ad hoc Network (MANET) is a specific kind of wireless network, it can be deployed without any pre-existing infrastructure. Each node acts as a router or a switch connected by the wireless connection. The combination of all these connections may form an arbitrary topology and the network either functions independently or connects into internet. An important characteristic of MANET architecture is it can change its topology due to the movement of devices. Fig. 1 shows the architecture of MANET [2].

Fig. 1 Architecture of MANET

The advanced features of MANET make the network to grow their applications rapidly. Due to this rapid development of MANET, it needs stability among their network for providing better connectivity. Clustering is one of the most popular techniques to provide stability among the network. It is a best approach for dealing the maintenance of mobile Ad hoc networks by partitioning the network into various groups of nodes called as clusters.

In a clustering, the mobile nodes are divided into different virtual groups and they are allocated geographically adjacent into the same cluster according to some rules with different behaviors of nodes. Cluster structure makes Ad hoc networks to be appeared as smaller and more stable. Clustering helps to improves routing at the network layer by reducing the size of the routing tables and by decreasing transmission overheads of routing tables after topological changes. Clustering contains three types of nodes such as Cluster-Head, Cluster Gateway, and Cluster Member. Fig. 2 shows the architecture of clustering [3].

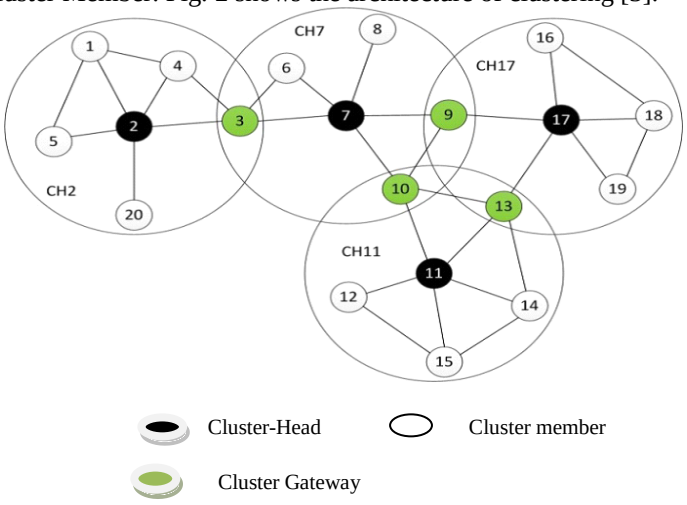

Fig. 2 Clustering Architecture

Cluster-Head serve as a leader node for its Cluster. Through Cluster-Head any node can easily communicate with each other. It performs responsible duties like inter-clustering, intra-clustering, data packet forwarding and maintenance of the entire network. Cluster Gateway is a non-Cluster-Head node and it provides link between two clusters. It is also called as Border node in Cluster and it provides access to neighboring cluster and transfer data packet between clusters. Ordinary nodes in the Cluster are called cluster members. It is neither Cluster-Head nor Border nodes. It does not have any inter cluster links [4].

Clustering can be considered the most important unsupervised learning problem. So every other problem of these kind deals with finding a structure in a collection of unlabeled data. The loss definition of clustering could be the process of organizing objects into groups whose members are similar in some way. The goal of clustering is to determine the intrinsic grouping in a set of unlabeled data. Clustering methods allows fast connection and also better routing and topology management of mobile ad-hoc network (MANET). Hence, this paper proposed the position and distance based clustering approach for further improvement of the performance of the network. The paper is organized as follows: Section II presents the analysis of clustering approaches, Section III describes the proposed position and distance based clustering approach, Section IV gives the analysis of the proposed work, Section V evaluates the performance of four clustering approach and section VI concludes the paper.

II. Literature Survey

MANETs are a promising way to offer internet access to wireless mobile devices. Clustering process plays a main role in providing effective communication in the network. The nodes in the network are divided into various clusters. Then each cluster selects a Cluster-Head which act as a coordinator for that cluster. The cluster formation and Cluster-Head selection uses certain rules and algorithms for their clustering. Many authors reviewed the clustering algorithms proposed earlier using the metrics mobility, energy, weight, distance, degree and load etc. Sunil pathak et al [5] proposed a new mechanism for merging two clusters. The cluster formation method takes two most vital factor node degree and bandwidth which are required for the construction of the cluster and selection of the cluster-head. Further, when two clusters come closer to each other they merge and form one cluster. The stated method makes cluster more stable and minimizes the packet loss. Adabi et al [6] proposed a Score Based Clustering Algorithm (SBCA), which aims to maximize the lifetime of mobile nodes and minimize the number of clusters. The algorithm uses the Remaining battery power, Node edge, Number of nodes, and Node stability as the metrics to calculate the node score. The proposed method generated the

minimum number of clusters. Madhvi Saxena et al [7] proposed a Max-Heap Tree algorithm which is based on energy efficient clustering. In proposed algorithm, small number of clusters is formed using Max-Heap Tree. Cluster head is elected based on the energy level of nodes where the highest energy level of node becomes the CH. The proposed algorithm minimizing the power consumption and maximizes the network lifetime.

Ni et al [8] proposed a mobility prediction based clustering scheme (MPBC) for MANETs with high mobility nodes. MPBC is considered the relative speeds estimation for each node in the whole network. MPBC clustering scheme mainly include two stages. All nodes broadcast the Hello packets periodically to build their neighbors lists during the clustering stage. Nodes are selected as CHs with lowest relative mobility. During cluster maintenance stage, prediction based method is used to solve the problems caused by relative node movements. This increases the network connection lifetime which results in stable clusters.

Priya saxena et al [9] proposed an energy efficient technique for improving the energy consumption in mobile ad hoc network and a new solution based on the energy efficient weighted clustering technique approach. The proposed technique promises to reduce the energy consumption in ad hoc network by using the cluster addressing and the efficient cluster head selection.

III. Proposed Position And Distance Based Clustering Approach

The goal is to build an architecture based on clustering process. Every cluster has some nodes based on its position. It also has a Cluster-Head node for providing communication across the nodes in the cluster. The Cluster-Head is selected based on the distance of the nodes from each cluster's center point. The clusters can communicate with each other through its corresponding Cluster-Head.

The following assumptions were made in the proposed work.

- The dynamic network topology with 100 nodes is considered.
- Each mobile node can be able to join with exactly one Cluster-Head.

The proposed work contains the following tasks:

- Cluster Formation
- Cluster Head Selection

3.1 Cluster Formation

Cluster formation is one of the main tasks in the proposed clustering approach. In this cluster formation process, first it finds the center point of the total network area. Second, it retrieves the position of all the nodes from the structure of the node. Finally, it divides the total network area into different number of clusters depending upon the number of clusters required. This division is based on comparing each and every node's position against the center point. The following algorithm shows the steps involved in the cluster formation process:

Algorithm :

Find the Center Point of network area

Layout_centerpoint(cpx,cpy)= Center_Point(Simulation_area)

Finding nodes position

For all nodes $Node_i$ in Simulation_area

$Node_i(x,y) = Node_i(xpos, ypos)$

End loop

Clustering Process

Compare nodes' x and y position against center point cpx and cpy. Depending upon the position of the node, the nodes are grouped into different clusters. For example, the following statement shows how the nodes are divided into four clusters based on I represents index of its position.

- Checkif($Node_i(x)$<=Layout_centerpoint(cpx) and $Node_i(y)$ <= Layout_centerpoint(cpy))Cluster1 = $Node_i$
- Else Check if ($Node_i(x)$>Layout_centerpoint(cpx) and $Node_i(y)$ <= Layout_centerpoint(cpy))Cluster2 = $Node_i$
- Else Check if ($Node_i(x)$<=Layout_centerpoint(cpx) and $Node_i(y)$ >Layout_centerpoint(cpy))Cluster3 = $Node_i$
- Else Check if ($Node_i(x)$ <= Layout_centerpoint(cpx) and $Node_i(y)$ >Layout_centerpoint(cpy)) Cluster4 = $Node_i$

3.2 Cluster-Head Selection

Cluster-Head Selection is another task involved in the proposed clustering approach. Initially, it finds the center point of each cluster. Second, it calculates the distance of each node in the cluster from its center point. Then the Cluster-Head is selected by choosing the node which has minimum distance from its center point. This process is repeated for all clusters in the area. The following algorithm shows the steps involved in the Cluster-Head selection process.

Algorithm :

Finding Cluster's Center Point

Cluster_cp(ccpx,ccpy)= Center_Point(Cluster_area)

Distance Calculation

For all nodes$Node_i$ in Cluster C,

$Node_i$.distance =

$\sqrt{[(C.ccpx-Node_i.x)^2 + (C.ccpy-Node_i.y)^2]}$

End loop

Choosing Cluster-Head

Cluster.Cluster-Head = min($Node_i$.distance)

IV. Analysis Of Proposed Clustreing Approach

The proposed position and distance based clustering algorithm is evaluated using AODV protocol by considering the metrics such as packet delivery ratio, dropped packets and end-to-end delay. The simulation parameters are shown in Table 4.1. Fig. 3 shows the simulation layout of the proposed work.

Table 4.1 Simulation Parameters

Parameters	**Value**
Number of nodes	30
Simulation Time	150sec
Area	800*800m
Max Speed	10 m/s
Traffic Source	CBR
Packet Size	512 Bytes
Bandwidth	10Mbps
Transmission Rate	64 kbps
Maximum Connections	9
Mobility model used	Randomway point

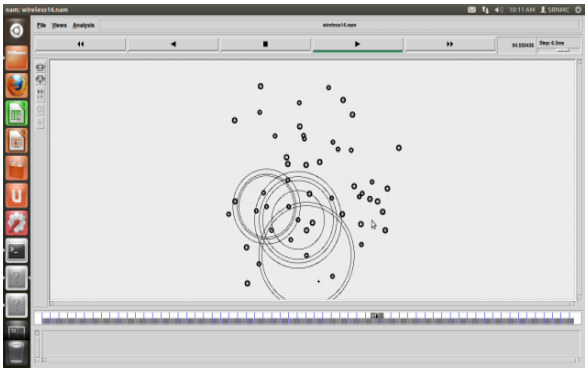

Fig. 3 Simulation Layout

The performance of the proposed position and distance based clustering approach is analyzed by comparing against traditional approach. In traditional approach, there are no clusters formed and all nodes in the network area are treated as conventional Ad hoc network. In two Clustering approach, the nodes in the network are grouped to form two clusters either horizontally or vertically based on its position. In four Clustering approach, the nodes in the network are grouped to form four clusters: Cluster-1, Cluster-2, Cluster-3 and Cluster-4 based on its position.

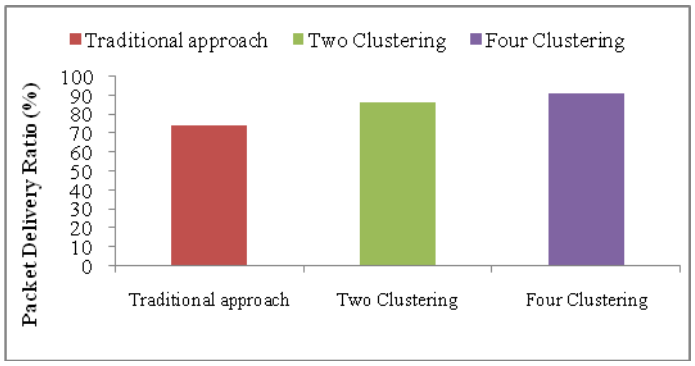

Fig .4 (a) Packet Delivery Ratio

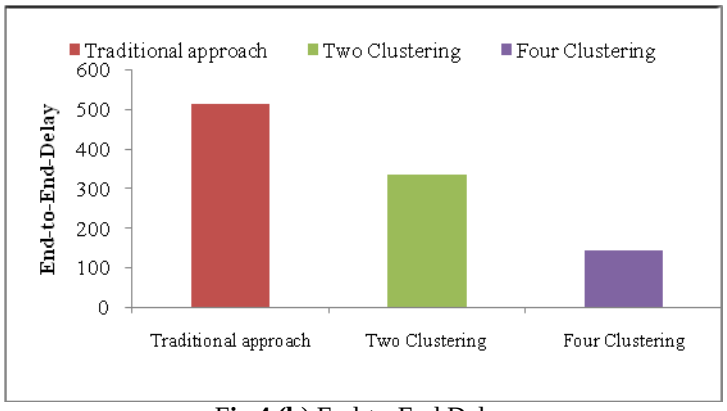

Fig 4 (b) End-to-End Delay

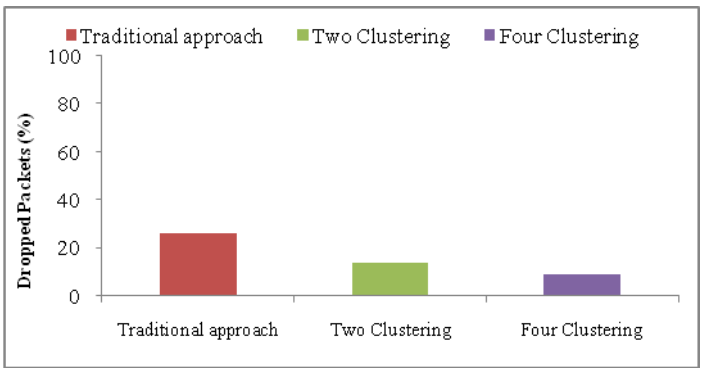

Fig 4 (c) Dropped Packets

Fig. 4 performance of proposed clustering approach

Fig. 4 shows the performance of proposed approach with two clustering and four clustering on the basis of packet delivery ratio, end-to-end delay and dropped packets by comparing against traditional approach. From Fig. 4(a), it is clear that the PDR value gradually increases when the numbers of clusters are increased and does not show better results when the clusters are not formed. From fig .4 (b), it observes that the delay value is gradually decreases with clustering and does not show better results for traditional approach. From Fig. 4 (c), it is clear that the dropped packets are gradually decreased when the clustering numbers are increased**.** While evaluating the performance of the proposed work by using AODV protocol and comparing against traditional approach it reveals that the proposed position and distance based clustering approach shows better performance in all the considered metrics. Moreover, the performance is increased when the numbers of clusters are increased. The four clustering approach provides better performance than the two clustering approach. Hence, the four clustering approach is considered for further study.

V. Performance Evaluation Of Four Clustering Approach

The further analysis was conducted in the simulation layout to evaluate the performance of the proposed four clustering approach using AODV routing protocol by varying maximum connections and transmission rate. The simulation results are shown in the form of bar graphs. The transmission rates are varied from 0.032 Mbps to 0.512Mbps for each connection of 4, 6, 8, and 10.

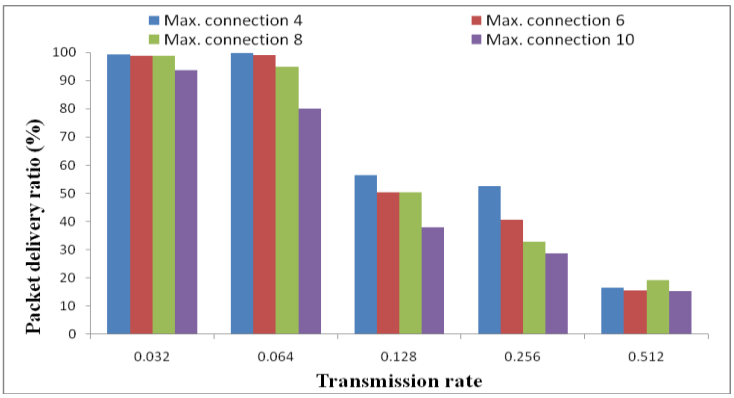

Fig .5 (a) Transmission rate Vs PDR

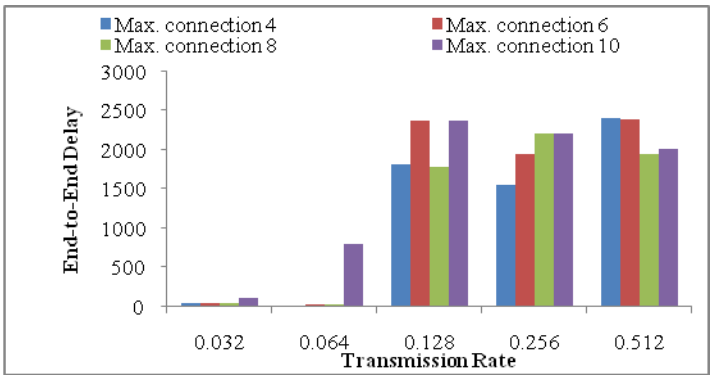

Fig .5 (b) Transmission rate Vs end-to-end delay

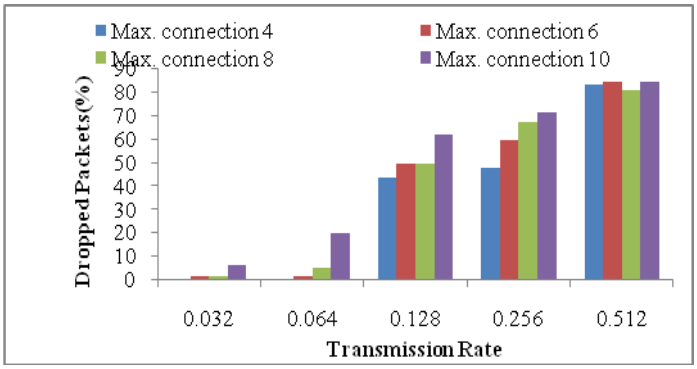

Fig. 5 (c) Transmission rate Vs Dropped packets

Fig. 5 performance evaluation of four clustering approach

Fig. 5 shows the performance evaluation of four clustering approach by using the considered metrics by varying the transmission rate and maximum connections. From Fig. 5(a) it is clear that the PDR is 80% to 99% at transmission rates from 0.032 Mbps to 0.064 Mbps by varying maximum connections 4, 6 and 8. The PDR value is high at the transmission rate of 0.064 Mbps with the maximum connection of 4 and it decreases from the transmission rate of 0.128 Mbps. Thus the ideal range of transmission rates are from 0.032 Mbps to 0.064 Mbps and the connections are 4, 6, 8 and 10. From the observed results of Fig. 5 (b) the ideal range for decreasing the dropped packets are from transmission rate of 0.032 Mbps to 0.064 Mbps for all the considered maximum number of connections. From Fig. 5 (c) it is clear that the delay decreases with the transmission rate 0.032 Mbps to 0.064 Mbps in the maximum number of connections 4 to 10. The delay increases from the transmission rate 0.128 Mbps.

VI. Conclusion

In this paper, the Position and Distance based Clustering approach is proposed to provide the stability of the nodes and to reduce the delay in the network. The performance of the proposed Position and Distance based clustering approached is analyzed by considering the metrics packet delivery ratio, dropped packets and end-to-end delay. Initially, the proposed work is considered as Two Clustering and Four Clustering approach

and they were compared against traditional approach. From the observed results, it indicates that the Two Clustering process in proposed work increases the packet delivery ratio by 16.33% and it reduces the dropped packets by 87.62% and delay by 53.03% whereas the Four Clustering approach in proposed work increases the packet delivery ratio by 22.52% and it reduces the dropped packets by 86.19% and delay by 49.62% when compared with traditional approach. The above analysis clearly indicated that the performance of the proposed work is improved when the number of clusters is increased. Thus the Four Clustering approach shows better performance in all the considered metrics.

The further analysis was done on the Four clustering approach by varying the transmission rate and the number connections. The transmission rates are varying from 0.032 Mbps to 0.512 Mbps for each connection 4, 6, 8, and 10. The analysis indicated that the transmission rates from 0.032 Mbps to 0.128Mbps and connections 4, 6 and 8 provides acceptable results in all the considered metrics. Hence, the results of the above considered metrics proved that the proposed Position and Distance Based Clustering approach provides stable connectivity and minimum delay in MANET. In future, the proposed work is enhanced by considering more factors for cluster formation and Cluster-Head selection.

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