A REVIEW OF CLUSTERING BASED ROUTING APPPROACHES IN VEHICULAR ADHOC NETWORK

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Abstract

VANET is basically a collection of the moveable devices and in-built sensors which make them more intelligent which has goals to manage and control over the issues in the transportation, congestion and accidental ratio. To enhance the vehicle roads safety, traffic efficiency intelligent transportation system in VANET has become a popular area. Vehicles in the VANET gather a lot of distinct information through road traffic and environmental conditions but it is very difficult task to transmit it to the destination with high mobility and in particular time domain. Clustering is highly needed in the VANET to group the vehicles to reduce traffic overhead. In this paper, we have described the use of clustering based routing approaches in the VANET which helps in selection of the cluster head and helps in maintaining the cluster stability through long time. The paper analyse different clustering techniques and their merits and demerits.

Keywords:- Vehicular Ad-hoc Networks, Intelligent Transport System, Road side Unit, Clustering, Routing Protocols

I. INTRODUCTION

VANET is taken as a special type of MANET that consists of moving vehicles and fixed road side units which helps in monitoring all types of communication in the network. VANET enables the digital data interaction between the vehicle nodes through the IVC i.e. inter-vehicle communication and between the RSU and vehicles via VRC i.e. vehicle to roadside communication. As the range is limited in the VANET in the terms of speed and direction, the vehicle always move in an organized way [1].

The mobile communication techniques have transformed the automotive industry since the last decade, by providing anytime anywhere communication between different devices. This ease of communication allows exchange of valuable information between devices just on the go. The seamless exchange of information on real time bases has turned out to become a new paradigm in the industry. Correspondingly, the advances in the information technology and the communication have easily supported the idea of communication between mobile devices. Among these advancements, the concept of VANET came into limelight which has opened new possibilities to avail the use of safety applications [2]. VANET is generally defined as a peculiar kind of network where nodes are represented as 'vehicles' that holds the capabilities of transmitting the data across the network. VANET is also considered as a substitute of Mobile Ad-Hoc Network[3]. There has been a considerable awareness and progress in the field of VANET's, due to its higher nodes mobility and dynamic topology. The aim of VANET is to provide efficient and safe transportation.

On the basis of VANET, ITS can be used for improving the efficiency of the network and even reduce the transportation and consumption of fuel. In the ITS , every vehicle takes the character of receiver, router and sender to transmit information to the network or transportation office [4].

For interaction between moving units and RSUs, the moving unit should be fortified with On Board Unit or radio interface (OBU) which permits less the formation of wireless ad hoc networks. Vehicles are fitted with the hardware which permits the information about the positioning such as differential global positioning system and global positioning system. The units in the roadside are associated to the mainstay network, so these units should have to be in the position to ease interaction [5]. The distribution of the roadside unit is fully dependent upon the communication protocol. As in some cases, protocols are fully based on the road side unit which are to be dispersed consistently in the whole network. In some communication networks only for the interaction purpose RSU are required and for some areas as the border regions.

For this handling, managing and controlling firstly the clustering of vehicles is needed to overcome the problem of the traffic problems like traffic overheads by choosing the responsible (in-charge) nodes which are known as the cluster heads. There are numerous number of clustering methods for balancing the load and prolonging the node great lifetime. The cluster based routing approach is a great idea if the user wants to get the efficient management of the network topology [8].

Each participating vehicle is turned into a router or wireless node that can connect and become a part of the network in

the range of 100 m to 300 m approximately. Network is dropped out in case vehicles fall out of the range. Any vehicles can join in the network, if it comes in the range to form a VANET. Each vehicle in VANET is considered as a mobile node which is proficient of communicating with its neighbours as well as with other vehicles within the network. The direct communication that takes place between on vehicle to another vehicle is called as Vehicle to Vehicle (V2V) communication, whereas on the other hand, communication between a vehicle and an infrastructure, such as a Road Side Unit, is generally known as Vehicle-to-Infrastructure (V2I) Communication [6]. The actual purpose of VANET is to allow wireless communication between the vehicles on the road including the roadside wireless sensors, enabling the transmission of information to ensure driving safety and planning for dynamic routing, permitting mobile sensing as well as providing in-car entertainment [7].

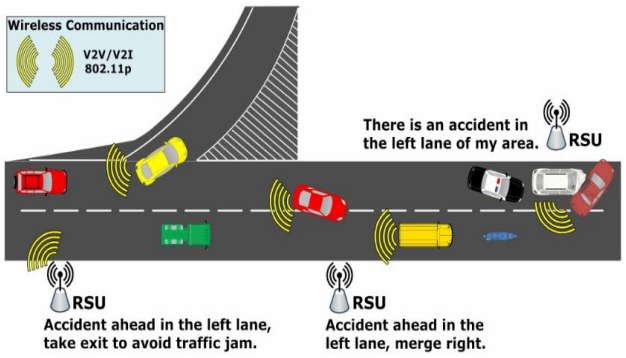

Figure 1 Vehicular Ad- Hoc Network [23]

VANETs can be utilized for a broad range of safety and non-safety applications, allow for value added services such as vehicle safety, automated toll payment, traffic management, enhanced navigation, location-based services such as finding the closest fuel station, restaurant or travel lodge and infotainment applications such as providing access to the Internet [9]. One of the leading applications of VANET is in the critical medical emergency conditions where there is no infrastructure while it is critical to pass on the information for the security of human lives. However, along with these useful applications of VANET, emerge new challenges and problems. Non-existence of infrastructure in VANET lays added responsibilities on vehicles. Every vehicle becomes part of the network and also manages and controls the communication on this network along with its own communication requirements.

Architecture of network has moving units which basically contain two components:

1. An on-board unit (OBU) which has communication capabilities in it.
2. An application unit (AU) are used for executing programs which enable OBU.

The infrastructure environment of the VANET consists of Road side units and different access networks. Two different types of communication occur in VANET network i.e. V2V is purely wireless communication between the vehicles whereas V2I is a communication between the nodes and the infrastructure units such as Road Side Units or any cellular network as depicted in fig. 2 [9].

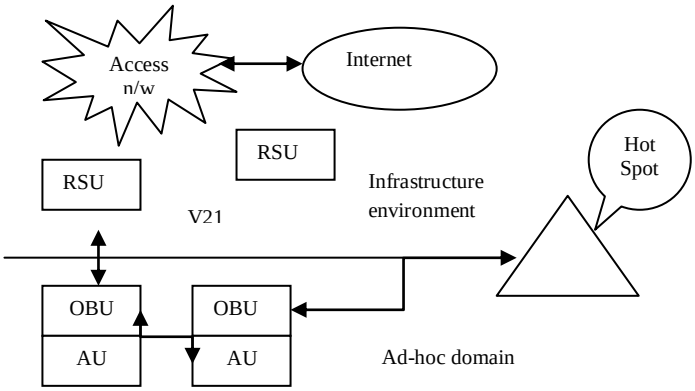

Figure 2 Architecture of a VANET

VANET is different from other ad-hoc networks of the similar class in some terms:

- Large storage capacity.
- High processing power
- Energy abundance
- Movement of nodes are predictable [9].

1.1 Clustering

Clustering is generally nodes group in which every cluster has the cluster member (CM), cluster head and the cluster gateway.

A VANET clustering algorithm happens to work by connecting the mobile nodes into clusters in accordance to the rule set and then choosing one CH (cluster head) which will help to communicate between the cluster and the network in the same way as the wireless access point works. Every cluster head have some distinct priorities. The main focus of the clustering algorithm is to combine the nodes with the group (clusters) which ought to be robust to node mobility and abrupt network changes [12]. The ratio of cluster head is defined as proportion of number of cluster heads to the sum of nodes. If the ratio is less it means network steadiness is improved [22].The main focus on the clustering was initiated with the DARPA packet radio network which is a part of mobile ad-hoc network which support network resource distribution [13]. There are various

clustering algorithms in the VANET which are described as follows in Figure 3 which are further classified into clustering algorithm:-

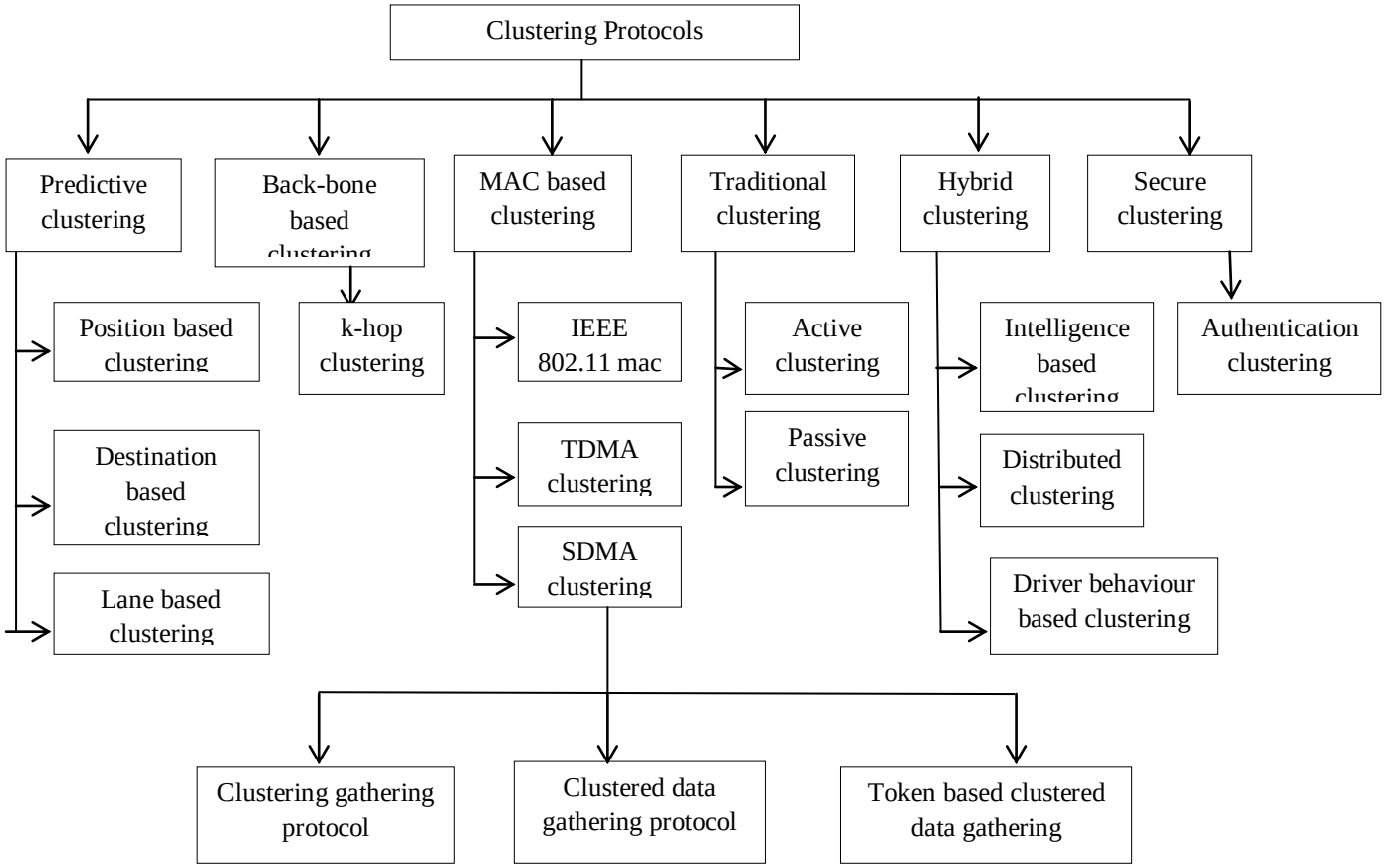

Figure 3 Current clustering methods for VANET

a. Predictive clustering

In this type of clustering the structure of cluster is found by the geographical vehicle position and its next behaviour. The information about the vehicles helps in making priorities in the traffic and then support in the cluster formation. To form the cluster in the VANET, the future positions and the intended destinations of the moving units has been used. There are further types of the predictive clustering which is described in the below table 1.

Table 1 Categorization of predictive clustering

S.No.	Clustering algorithm	Description	Merit	Demerit
1.	Position based clustering [11]	- It form the clusters which is particularly dependent upon the geographical location of the vehicle and the cluster head. - Some of the position based clustering algorithms are as follows: (ALM, cross layer algorithm , modified clustering based on direction in VANET and DMAC algorithm.	- Rely on position of vehicle, values of vehicle density and even the vehicle speed. - Cluster convergence rate is less even when the density of vehicle and cluster dynamics upsurge which accounts for better cluster stability.	- The cluster size variance sometimes affects the performance. - Transmission efficiency is low which has effect on the PDR (packet delivery ratio).
2.	Destination Based Clustering[12]	- It takes in the existing position, relative, speed and the destination of the vehicle	- For keeping the process of cluster stable, the cluster changes frequency is	- High transmission overhead due to high traffic of vehicles in

		for the formation of the cluster. - By the navigation system the destination is known. For improving the GPS in the previous studies the algorithm of Location improvement with cluster analysis (LICA)	lessened, as the vehicle encounters new CH. - Thus knowing the behaviour of the vehicle by forecasting the destination increases its stability. - More efficiency in transmission of message.	the cluster.
3.	Lane based clustering [12]	- It forms or creates the cluster on the basis of the vehicle lane estimation taking in account the specific parameters.	- It uses the lane statistics to form and choose the stable clusters. - Less transmission overhead. - Enhance transmission efficiency as the cluster head lifetime is better and have better transferring reachability. - Small delay overhead so cluster is successfully maintained for vehicle in the network. - Good for urban environment.	-

b. Backbone based clustering

It creates a backbone for the communication of clusters. It basically performs the interaction and chooses the cluster head from the cluster nodes. There are various types of the backbone based clustering algorithm which are described in the table 2 below [15].

Table 2 of backbone based clustering

Algorithm	Description	Merit
K-hop clustering [16]	- In this clustering algorithm the structure of the cluster is controlled and monitored by the hop distance. - The distance between the various clusters and the Cluster head should have previously defined amount of hops which can be one or more.	- For enhancement of the efficiency of the cluster, the multi-hop method takes the advantages of the k-hop algorithm. - Better cluster stability. - Less cluster variability - Thus less CH variation and prolong life of the cluster. - Improved and reliable method for the VANET.

c. MAC based clustering

For the process of the cluster formation various MAC based clustering approaches are defined in the previous studies. This method takes in account IEEE 802.11 MAC protocol for the creation of the clusters. There are various types of the MAC based clustering which are described in the table 3 [17]:

Table 3 Categorization of MAC based clustering

S. No.	Algorithm	Description	Merit	Demerit
1.	IEEE 802.11 MAC Based Clustering[26]	- It has message delays and even upsurge number of collisions. - Increased disagreement when vehicle speed increases.	- Some integration is need with this protocol to make it faster.	- Lower transmission efficiency - High transmission overhead
2.	TDMA Based Clustering[17]	- The time slots are given for the data transmission using the TDMA method	- It is used for optimizing the communication and accessing of medium in the cluster. - Inter cluster collision is minimized through these clustering protocols. - Packet loss is reduced. - Share the wireless medium in time slots. - Smaller multi–hop message delays. - Better efficiency for the maintenance of the cluster which enhances the intra and inter communication throughput.	- Sometimes bottle neck occurs due to high clustering union in the time slots given by the TDMA.
3.	SDMA Based Clustering [17]	- The way is divided into static length segments and again a particular segment is divided into the number of blocks. - Every block is given timeslot which shows the time allowed by that vehicle to transfer data.	- Better performance in the thick network. - Clustering data gathering protocol with the dynamic space division multiple access is collaborated for transmission process. it gives the lower collection efficiency. - For resolving the issue of less collection efficiency token based cluster data gathering protocol is used in further studies.	- With the decrease in the density the performance decreases. - In the sparse networks, this SDMA based clusters algorithm shows poor performance.

d. Traditional clustering

This clustering is mainly dependent on the role of nodes for cluster formation. The types of traditional clustering are described in the table 4 which involves two types of clustering.

Table 4 Categorization of traditional clustering

S. No.	Algorithm	Description	Merit
1.	Active clustering [29]	- Continuous updates about the information of the cluster formation or the change in the routing tables after the fixed time domain. - The clustering process is started by the process of flooding which creates the constant routing overhead. - Clustering protocols are: mobility based clustering, beacon based clustering, dynamic and density based clustering.	- It creates the less overhead for the maintenance of the cluster
2.	Passive clustering [29]	- It passively creates the cluster structure. - The vehicle in the passive clustering easily maintains the overhead in the packet flooding with the use of on-going data packets.	-

e. Hybrid clustering

In this case of hybrid clustering, the existing techniques are combined which can organize and handle the cluster ad cluster head in the better way. It may contain the artificial intelligence and the fuzzy logic. It has two types which are describe in the table 5 described below.

Table 5 Categorization of Hybrid clustering

S. No.	Algorithm	Description	Merit	Demerit
1.	Intelligence based clustering [25]	- Due to higher cluster head and member duration, it give higher cluster stability. - As the vehicle density increases, the parameter's value improves.	- Higher cluster stability.	- As the transmission overheads are high thus it reduces the PDR (packet delivery ratio), so the transmission efficiency is reduced.
2.	Cooperative Decentralized clustering [25]	- It is being investigated for the more good intelligent transportation solution and more secure traffic management.	- Cost effective traffic monitoring system are supported.	- Lower cluster stability - Less connect time of cluster. - Higher transmission overhead and inferior the density of the vehicle, the intra-communication of cluster is reduced.
3.	Driver behaviour dependent Hybrid Clustering [25]	- Vehicles in the VANET network have sensor which gather and transfer information to the other vehicles or the wireless sensors to avoid accidents and collision.	- Efficiency of the network is enhanced. - Good cluster lifetime. - Good stability of clusters.	- Suitability of the vehicle environment and the parameters should be considered time to time to maintain the cluster stability.

f. Secure clustering

VANET assist for various live applications which work for the safety of vehicles on road, thus enhancing the road transportation network. The authentication clustering also provides a secure communication in the vehicular through the public key infrastructure which includes the certificate authority for certifying the vehicle public keys.

1.2 Cluster creation using K-mean and modified K-mean

The basic idea for the K-mean is to recognize the cluster points for the vehicle classification. The dedicated short range communication is taken which has 3 parts. Every part or the cluster point is defined by the cluster. In the particular range, the 3 cluster points C1, C2 and C3 are taken as thecentroids of the 3 different clusters of vehicles. The confidence interval, mean of the vehicle velocities are considered. The expectation and means of the vehicle velocity are taken for choosing of the vehicles for the clustering.

After this, selections of the vehicle head for the cluster which can responsible take whole the qualities are done. It is a very critical procedure. The HELLO message is transferred between the vehicles. The centralized vehicle is selected by different algorithm like Floyd Warshall algorithm.

The selection of the cluster heads are according to some criteria. The main objectives are reliability, throughput and performance of the network. There are some criteria for selection of cluster like time and passive clustering is described in table 6.

Table 6 Selection criteria for the selection of cluster head on the basis of time and passive clustering with application and its simulation the basis of previous studies.

Algorithm	**Selection metric**	**Neighbour Discovery**	**Application**	**Affiliation Handshake**	**Cluster head handoff**	**Simulator**
CCP (Cluster Configuration Protocol)[30]	RSS	Hello	Quality of service assurance	No	No	unspecified
SBCA (Stability Based Clustering Algorithm)[30]	RSS, relative velocity	Hello	Quality of service assurance	No	Yes	NS-2
CBMAC cluster based MAC) [30]	Static time out	Hello	Channel access management	Yes	No	Custom
HCA (Hierarchical Clustering Algorithm) [27]	Random timeout	Hello	Channel access management	Yes	No	VEINS
DBA-MAC (Dynamic Backbone-Assisted MAC) [30]	Link expiration time	Hello	Routing	Yes	No	NS-2
CBLR (Cluster-Based Location Routing) [27]	Static timeout	Inquiry	Routing	Yes	No	OPNET

II. RELATED WORK

The previous studies on the clustering based routing in the VANET have been studied and analyzed. The different clustering based approaches in VANET by different authors are compared as P.Papadimitratos et al. [20], designed approach aims at a system that relies on well-understood components which can be upgraded to provide enhanced security and privacy protection in the future. This effort was undertaken by SeVeCom (http:llwww.sevecom.org), a transversal project providing security and privacy enhancing mechanisms compatible with the VC technologies currently under development by all EU funded projects. This paper presented the basic ideas of a security architecture for vehicular communication systems, with the focus on communication. The basic objectives of the proposed architecture, in the context of the Sevecom project, are: identity and cryptographic key management, privacy protection, secure communication, and in-car protection and tamper-resistance. Claudio E. Palazzi et al. [19]**,**proposed a novel IVC architecture that adapts its functionalities to efficiently server applications by quickly propagating their messages over a vehicular network. In the paper author conducted an extensive set of experiments that demonstrate the efficiency of our approach. As representative case studies, it considered two application classes that, for their network traffic characteristics, are at the opposite boundaries of the application spectrum: safety and entertainment. IVC is the forthcoming frontier in mobile communication. A particularly interesting case study has been represented by distributed interactive applications run by vehicles spread in a few kilometres of range. This class of applications has been featured with the requirement of fast message delivery, through multi-hop broadcast, over the vehicular network. Jianqi Liu et al.[22],have presented the merits and demerits of the every particular protocol which is based on the clustering. the challenges , issues and the different protocols which can be hybridized for the better stability of the cluster and its prolong life were discussed. B. Hassanabadi et al. [14]**,** have proposed a mobility based scheme for the clustering in the vanet which use the affinity propagation algorithm. It takes in account the mobility of node in the creation of cluster and clusters are made with higher mobility. The proposed algorithm was highly robust and the reveals the overhead in the network. Superior performance was achieved with the proposed model. Mohamed Nidhal Mejri et al. [18],provided the summary of the recent state of the art of VANET. It also presented the communication architecture of VANET and outlines the privacy and security challenges that need to be the overcome to make such networks safety usable in practice. It defined all the security problems in the Vanet and classifies them from a cryptographic point of view. Yuzhong Chen et al. [16], have proposed a neighbourhood follow scheme called DMCNF. It permits vehicles to selects the targets from the neighbourhood one-hop distance in the distributed strategy. This scheme improved the stability of the clusters and even created the better cluster head with high life time. SeyhanUcar et al. [23], have proposed hybrid structure which combined the IEEE 802.11 p multi-hop based clustering and the fourth generation cellular system called as VMaSC-LTE. It achieved higher efficiency, higher packet delivery ration and less delay. It was based in the vehicular multi-hop method for the stable clustering. it has a lot of feature which improve the efficiency, making the hops less between the nodes, accurate consumption of resources and even the better selection of the cluster head. The proposed method achieved higher reliability in the data packet delivery ratio.

III . OPEN RESEARCH AREAS

Although there has been an ample amount of research in VANET, still there are many areas which need to be looked into. Due to the different nature of VANET form many other wireless communication networks and hard design requirements, there are many interesting research problems in this field. The paper summarizes some of the key research areas and challenges. However, it must be noted that the research challenges in VANET are not limited to only these areas. Provision of certain quality of service levels in VANET is an important task. A network with minimum delay for data delivery, less retransmissions, and high connectivity time can provide certain QoS guaranteed to the users. For timely delivery of data packets from one node to another node an efficient routing algorithm is required. In VANET, efficient routing algorithm means a routing scheme with minimum delay, maximum system capacity and less computational complexity. We need to design such an algorithm which can be implemented in multiple topologies of the network. Designing a scalable and robust network remains an open area of research in VANET because of its challenging characteristics. Many design approaches fall short when VANETs transform from sparse to high dense mode, or from high mobility to slow traffic scenarios. A complete VANET framework that is scalable to different network scales and robust to the topological changes is required. Different concepts of co-operative communication from wireless network theory may not be directly applied to VANET. This co-operative communication, such as up to which extent nodes should exchange information among themselves. As the nodes in VANET environment seek exchange of information among each other all the time, making sure that certain critical privacy information remains within the concerned node is an important design aspect.

Designing a proper authentication mechanism and a trust based security protocol is required.

IV . CONCLUSION

The main focus of this comparative research is to analyze all the clustering algorithm based routing in the VANET so that the cluster stability can be achieved. Different algorithm based on the position, neighbourhood, hierarchy, mobility and token are described. Every cluster approach has different variations according to the different topology, traffic, congestion and the algorithm used for the selection of the cluster head. The k-mean algorithm has achieved very good performance in the previous studies for the creation of the cluster head.

In previous work, it has been observed that there are a number of routing algorithms that are used to create a route from source to destination in order to transmit data. But, due to lack of route optimization process the chances of transmission failure become high. So in the future we would be working on optimization based cluster formation technique for improved cluster forrnation which can result in improving data dissemination with minimal delay, less packet drop ratio and high throughput.

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