# Clustering in Ad- Hoc Networks

## DISSERTATION-I

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## CERTIFICATE

This is to certify that Arshdeep Kaur bearing Registration no. 11602916 have completed objective formulation/Base Paper implementation of the thesis titled, **"Clustering in Ad- Hoc Networks"** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of thesis has ever been submitted for any other degree at any university.

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We are also indebted to all authors of the research papers and books referred to, which have helped us in carrying out the research work.

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# DECLARATION

I, Arshdeep Kaur, student of M. Tech under Department of Electronics and Communication of Lovely Professional University, Punjab, hereby declare that all the information furnished in this Dissertation-I report is based on my own intensive research and is genuine.

This report does not, to the best of our knowledge, contain part of my work which has been submitted for the award of my degree either of this University or any other University without proper citation.

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# ABSTRACT

Among the various technologies that are constructing its pillars deep in the field of engineering, there comes the ad- hoc networks. The ad- hoc network can be mobile and wireless network. The work is majorly stressed upon the vehicular ad- hoc networks (VANETs). VANET is an emerging technology sharing a plethora of applications providing safety and contentment to the vehicle users. It is a vital part of Intelligent Transport systems (ITS) which provides coherent and well organized communication between the vehicles like sending the warning messages to avoid the accidents and fatal conditions. Peculiar traffic conditions and the dynamic topology of the network can be challenging for the timely delivery of the messages. Though VANETs presents a unique range of challenges for routing, on the other hand it equally presents solutions via clustering algorithms.

Clustering can be useful in maintaining the stability and reliability of an ad- hoc network that results in performance enhancement. Clustering is basically a key technology in VANET that outperforms the MANET clustering algorithms like lowest ID algorithm, maximum degree algorithm etc. that does not perform well on the pitch of VANET. Adding to the merit of vehicular ad- hoc networks, they have a good hand in accident avoidance, congestion detection, information dissemination etc. The work outline presents comparative study of various clustering algorithms researched in recent years hence making it an easy task to examine the best algorithm for clustering in a particular situation and aims to propose clustering technique ensuring higher mobility and stability. Also, the clustering uncomplicated the issues of vehicular nodes by selecting the fittest CH on the bases of various parameters such as mobility metrics, cluster head or cluster member lifetime etc. Dynamic clustering scheme is stressed upon for providing the stability to the VANET network as it possess dynamic topology hence requiring stabilization and longer cluster head lifespan.

# LIST OF ABBREVIATIONS

| | |
|---|---|
| MANET | Mobile ad Hoc Network |
| VANET | Vehicular Ad- Hoc Network |
| CH | Cluster Head |
| CM | Cluster Member |
| CR | Cluster relation |
| V2V | Vehicle to vehicle communication |
| V2I | Vehicle to Infrastructure |
| RSU | Road Side Unit |
| OBU | On Board unit |
| AU | Authentication Unit |

# TABLE OF CONTENTS

**Title Page** **Page No.**

**PAC……i**

**CERTIFICATE……ii**

**ACKNOWLEDGEMENT……..iii**

**DECLARATION…….…....iv**

**ABSTRACT…….……v**

**LIST OF ABBREVIATIONS…… vi**

**LIST OF FIGURES…….ix**

**LIST OF TABLES……...x**

**CHAPTER 1: INTRODUCTION** **1- 10**

1.1 Introduction to ad hoc networks……1

1.2 Introduction to VANETs……2

1.3 Architecture of VANETs……4

1.4 Characteristics…….……....9

1.5 Applications……9

1.6 Advantages 10

1.7 Issues 10

**CHAPTER 2: REVIEW OF LITERATURE…….....11**
**CHAPTER 3: RATIONALE AND SCOPE OF STUDY……21**
**CHAPTER4: OBJECTIVE OF THE STUDY……23**
**CHAPTER 5: RESEARCH METHODOLOGY……24**
**CHAPTER6: RESULTS AND DISCUSSIONS……28**
**CHAPTER 7: CONCLUSION AND FUTURE SCOPE……..32**

**REFERENCES…….33**

# LIST OF FIGURES


| Figure | Caption | Page No. |
|---|---|---|
| Figure 1.1 | Ad hoc network | 1 |
| Figure 1.2 | Clustering in VANETs | |
| Figure 1.3 | VANET general Architecture | |
| Figure 1.4 | Cluster Formation in SABCA | |
| Figure 5.1 | Cluster Formation | |
| Figure 5.2 | General Clustering Algorithm | |
| Figure 6.1 | Average CH duration | |
| Figure 6.2 | Average CM duration | |
| Figure 6.3 (a) | Average number of UN for VMaAsC | |
| Figure 6.3 (b) | Average number of UN for 1- hop | |

# CHAPTER- 1
# INTRODUCTION

## 1.1 Introduction to Ad- hoc networks

Ad hoc is derived from a Latin word which signifies ‘formed for’. A network consisting of various independent individual devices sharing and exchanging information for communicating with each other resulting in formation of a multi hop radio network is termed as ad- hoc network. While communication, if the one party, who is interested to communicate with the other party but the they are far away from each other needs an intermediary to exchange the information, for the purpose of which ad- hoc network came into existence. It implies that if the desired target node is distantly located and is unapproachable then the message is transmitted via other nodes.

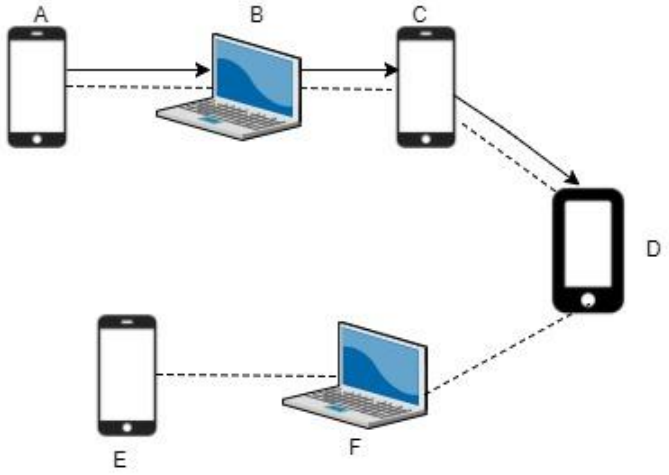



**Figure 1.1 Ad- hoc network**

An example of an ad- hoc network has been illustrated in the fig. 1.1, where devices independent of each are considered among which communication is going to happen. The information cannot be directly sent to D from A, for the purpose of which B, C are required through which A can communicate with D. these nodes can be smart devices like PDAs, laptops, mobiles etc. on the bases of infrastructure, the two of the popular areas in ad hoc networks are Mobile Ad- hoc Network (MANETs) and Vehicular Ad- hoc networks (VANETs).

In MANET the autonomous mobile users communicate over wireless links where nodes are mobile and the network topology is unpredictable. On the grounds of history, MANETs played a prominent

role in battlefield communication but later the miniaturization offered in wireless communication led to its popular usage made the way for major deployment of adhoc networks.

## 1.2 Introduction to VANET:

VANET consigns a prodigious discipline for researchers to provide autonomous wireless communication between various parties like vehicle to vehicle (V2V communication), vehicle to infrastructure communication (V2I), vehicle to broadband cloud computing, and in- vehicle communication. VANETs propound various opportunities in the field of traffic safety and connectivity of vehicles for efficient communication to obtain state information (speed, location, mobility information) [1]. Such matrices are chosen by the clustering algorithms as per their need and requirement. Now- a- days the vehicle has gone beyond of just being a transport to the intelligent transport system (ITS). VANETs are specifically liable to be influenced by the hidden nodes. Hence, the researchers proposed the unique idea of *clustering* in vehicular networks via of clustering algorithms. A cluster is a group of nodes that can communicate with each other and can transfer the information through a connection established between them. Each cluster has a cluster head whose purpose is to co-ordinate the communication among the nodes present in the cluster.

There are a number of clustering techniques proposed by various researchers to easify the formation of clusters by applying different clustering algorithms. Figure1.1 is a general description where the dynamic topology serves as an issue and stable clustering is used to resolve it. A highway is divided into two lanes where vehicular nodes (cars/ other vehicles) are moving with disparate velocities. The vehicles start forming a cluster using clustering techniques and the nodes in the cluster are called Cluster Members (CM) among which one node is chosen as the Cluster Head (CH) with the help of clustering algorithms. Various vehicular nodes form a cluster (cluster-A, B, C) as shown in fig.1.1, using clustering techniques like autonomous clustering, context aware clustering, decentralized clustering, dynamic clustering etc. The vehicles moving in a specific direction are a part of a clusters and other nodes coming in contact on the way also joins a cluster on request. For inter cluster communication between cluster- B and node cluster- C, a gateway plays an eminent role.

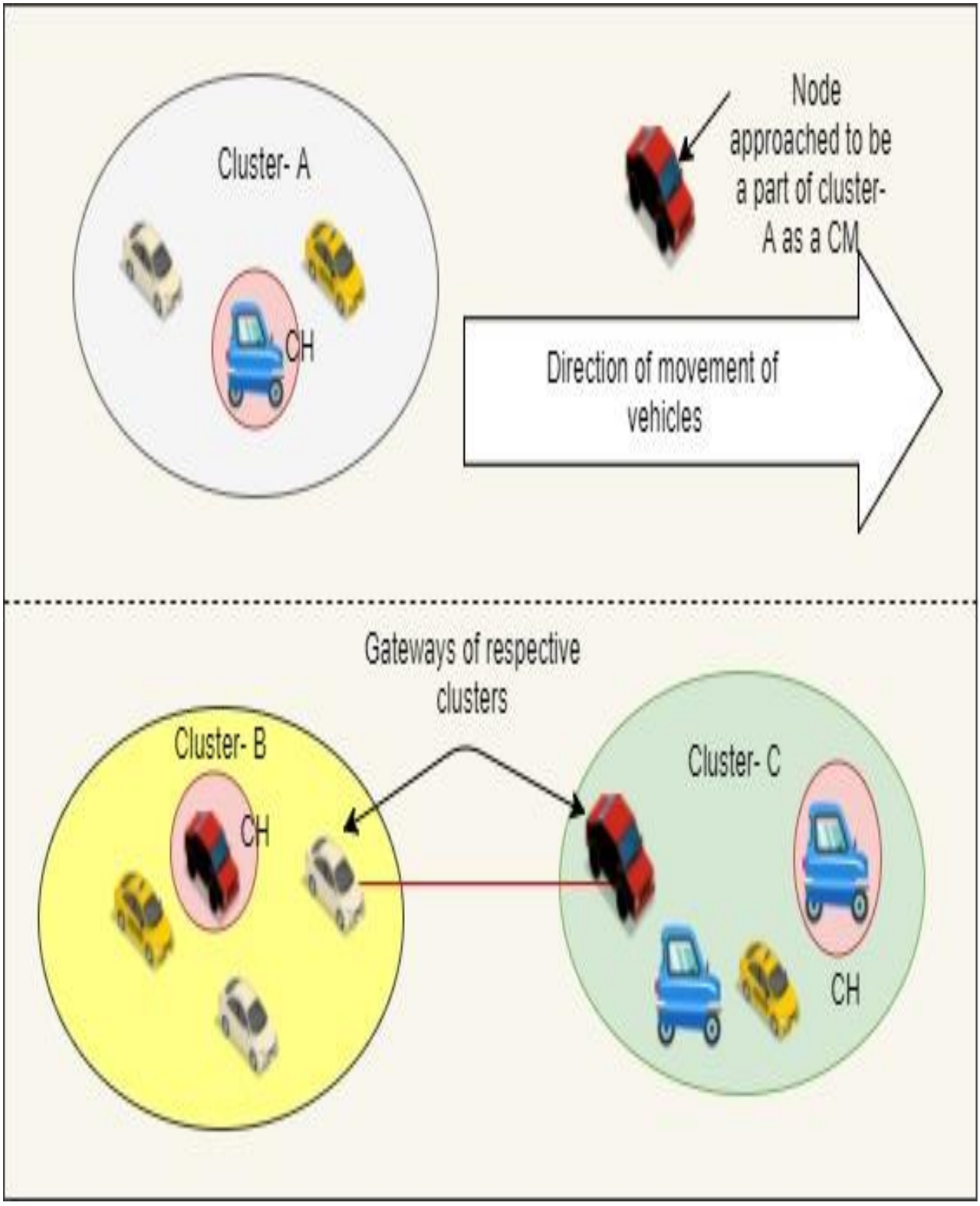



Figure 1.2 Clustering in VANETs

## 1.3 Architecture of VANETs:

As VANET creates a self-organizing wireless network using its mobile nodes, there also exists a full fledge architecture including other units as RSU, OBU, AU. VANET is a prime component of Intelligent Transport Network which aims at improving the traffic efficiency so as to provide a better safety on road. VANET possess a dynamic topology where occurs frequent connections and disconnections of the vehicular nodes. It offers:

- Large storage capacity
- High processing power
- Efficiency (in terms of power and energy)

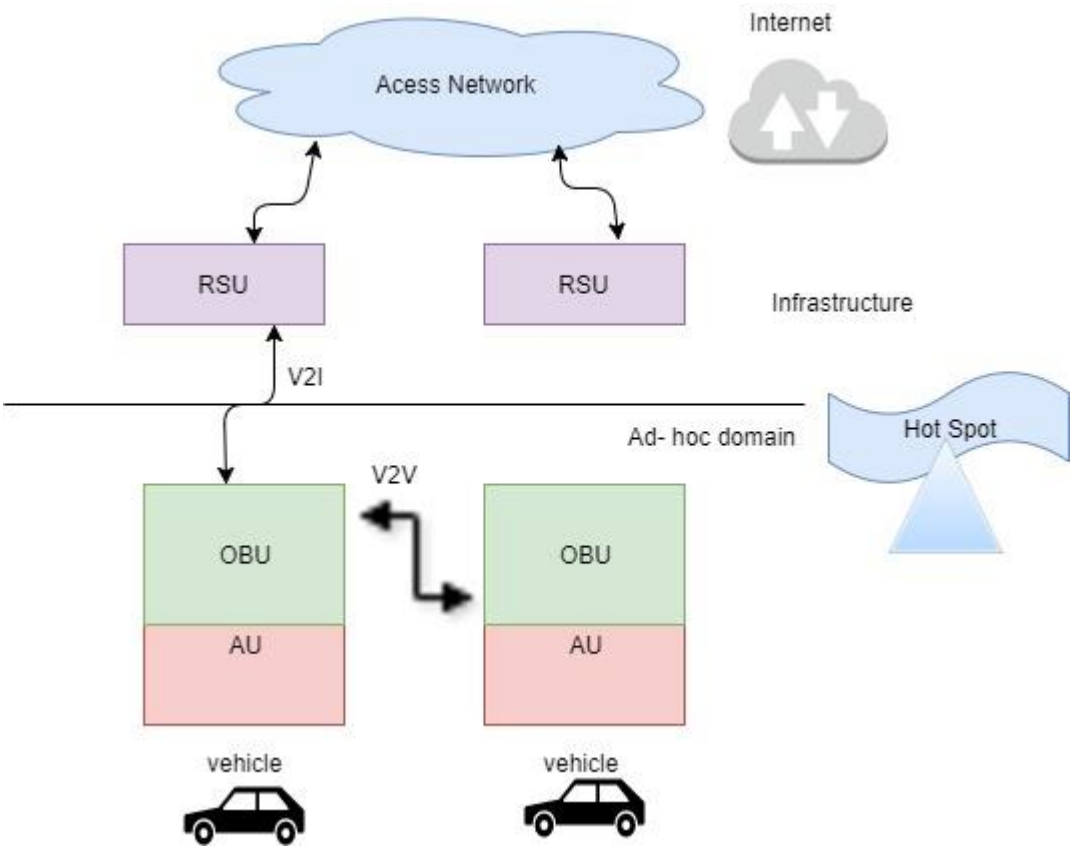



Figure 1.3 VANET- General Architecture

VANETs ensure:

- Traffic management

- Safety management, and
- Internet services

The VANET architecture follows Wireless Access in Vehicular Environment (WAVE) which is based on 802.11 standard protocol and is used in ITS. WAVE is a specifically designed standard protocol which supports the vehicular environment and also promotes the V2V and V2I communications in 5.9 band licensed for ITS and uses the multiplexing technique of OFDM to attain orthogonality so as to split the signals a. WAVE consists of RSU and OBU. Hence WAVE was adopted later. The units used in the vehicular ad hoc network are:

TABLE I. Units Description of VANET architecture

| Unit | Abbrev. | Description |
|---|---|---|
| Out Board unit | OBU | • Mobile node of an ad- hoc network<br>• Realises V2V communication<br>• Communication with other OBUs<br>• Data reliability<br>• IP mobility<br>• Network congestion control<br>• Radio access<br>• Ad hoc and geographical routing<br>• Data security |
| Authentication Unit | AU | • Communicates with network via OBU<br>• Responsibilities:<br>- Mobility<br>- Network functioning |
| Road Side Unit | RSU | • Based on IEEE 802.11p radio technology<br>• Provides internet connectivity to OBUs. |

It came into existence because fast communication was required due to the dynamic environment of vehicular scenario which demanded high speed transfer rate. Earlier the issue faced with 802.11a was its low data rate of 54 Mbps which ultimately resulted into multiple overheads. This protocol also permit the vehicles to have a direct communication with no authentication before joining the

network. Researchers are further emphasizing on providing the authentication and confidentiality assurance for security reasons.

TABLE II Communication Architecture

| Communication | Functions |
|---|---|
| In- Vehicle communication | • Vehicle performance detection<br>• Drivers physical condition<br>• Vehicle's inside environment for safety purpose |
| V2V communication | • Communication between two or more vehicles<br>• Sharing information:<br>- routing information<br>- Alerts<br>- Driver to driver information<br>• Naive broadcasting (periodic)<br>• Intelligent broadcasting (overcome overheads caused due to the generation of broadcast messages in large number) |
| V2I communication | • Communication between the vehicles and the infrastructure on the roads<br>• Weather updates with sensing and monitoring<br>• Vehicle density |
| Vehicle to Broadband cloud computing | • For the active driver assistance<br>• For vehicle tracking |
| Routing based communication | • Combination of V2I and V2V<br>• Presents a unicast method<br>• Message transmitted in multi hop fashion till the time it catches up with its destined vehicle. |

VANETs are a victim of frequent disconnections in the dynamic vehicular scenario where the unpredictable movement of the vehicles causes hindrance in the stability mechanism of the network.

Once the network is established, the information can be disseminated and shared via data packets. Since the vehicles are mobile in nature so connection maintenance is a tough task for moving vehicles where the neighbor nodes can also transcend the transmission range. As a solution to which access points in terms of relay nodes can be pre- deployed to maintain the connectivity of the network. The vehicles are equipped with the Global Positioning system (GPS) by virtue of which a vehicle can monitor the network and the nodes which will greatly be useful for collision avoidance and to attain information of location. Every vehicular node is required to fully process the raw information for the purpose of which it direly need a handsome storage capacity. So, it uses the rechargeable batteries whole sole purpose is to generate the power continuously hence making the network more efficient in terms of power and energy.

Clustering Framework of General Clustering Algorithm

- Scanning neighbor nodes
- Selecting the Cluster Head (CH)
- Affiliating the CH

### 1.3.1 Cluster formation

In the initial state, all the orphan nodes that are not a part of any of the cluster becomes to be ON (orphan Node) state. Member packet (MEP) is broadcasted periodically by the node state of ON. To make the neighbor nodes aware of its presence, MEP consisting its unique ID is broadcasted time to time. The node will declare itself as a cluster head when all the neighboring nodes have ON state. Management of the cluster is not such a tedious task. Whenever MEP consisting CH- ID is broadcasted, the nodes further transmit it to the nodes down the stream. In return, the nodes send back Member Ack Packet (MAP) to the parent node. In this way a CH based tree is formed for the cluster management. Discussing the cluster size, it is well bounded and curb by the upper and lower bounds U and L respectively.

| |
|---|
| CM< L= merger with one of the neighboring cluster |
| CM> U= cluster divided into two cluster by CM |

The merger of the cluster done by the pseudo code comes into the picture whenever the cluster member (CM) is lesser than L by sending Merge Query Packet (MQP). This is carried out by the cluster head which acknowledges with Merger Query Ack Packet (MQAP). The cluster merger ends up by assigning the own cluster ID to source node cluster ID. Hence merger completes by the recipient node of MQAP which will set the cluster ID.

A cluster is divided into two clusters whenever the value of cluster members exceeds the value of U.

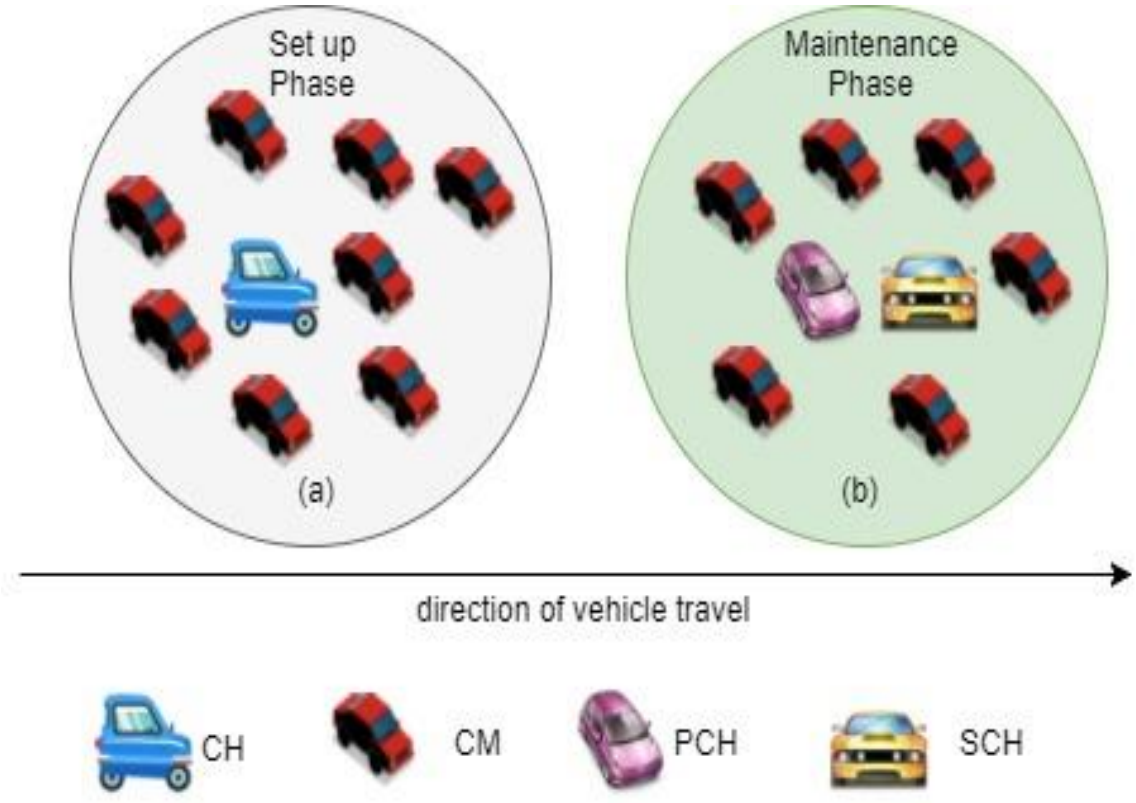



Figure 1.4 clusters formed by clustering scheme SABCA

### 1.3.2 Clustering algorithm

As clustering is an optimal technique to improve the issues like reliability, scalability, robustness, challenging environment, there exists various clustering algorithms that cope up with these issues effectively. Following are the reviewed algorithms that discusses the parameters, advantages and

issues faced while clustering. To enhance the better understandability a table of algorithms has been provided. In clustering algorithms, a hierarchical network structure is formed in distributed manner to attain the advantage of the infrastructure based network where the physical network is not required. While clustering when the destination is out of range of a direct communication then the neighbor nodes are used for packet routing.

Clustering algorithm uses the nodes in clusters:

- to provide end to end communication
- to ensure robustness towards mobility and dynamic VANET environment.

## 1.4 Characteristics :

- Low Bandwidth
- Short Range transmission
- Omnidirectional broadcast
- Intelligent Transport System (ITS)
- Time critical
- High mobility
- Unbounded network size

## 1.5 Applications

- General purpose algorithms
- Routing
- Channel access management
- Security
- Vehicular network topology discovery
- Traffic safety
- Combination with cellular infrastructure
- Collision avoidance

- Co- operative driving

## 1.6 Advantages

- Supports V2V and V2I communication
- Reduction in transmission overheads using clustering
- Efficiency
- Adaptability of the network
- No requirement of power back up
- Offers vehicular access of fast speed internet.
- Traffic safety

## 1.7 Issues

- Security and threats
- Dynamic topology
- Hidden nodes
- Scalability
- Stability maintenance
- Mobility prediction
- Delay Constraints
- Volatility
- MAC issues
- Geographical Addressing

# CHAPTER- 2

# LITERATURE REVIEW

**Wei Fan et. al. [1]** proposed a scheme of dynamic clustering on the bases of mobility metrics by considering the mobility and road constrained characteristics of VANET. The MANET algorithms definitely does not stand up- to- the- mark for high mobility environment which presented the dire need of VANET clustering algorithms. DCA helps in forming more stable clusters such that cluster lifetimes can be enhanced re-affiliation times for clusters can be minimized independent of the dynamic scenario of the environment. The major grasping thing is that the cluster structure is obtained by spatial dependence. DCA will elect the node with maximum CR value as the CH which will reduce the re- affiliation time and the minimum value of the cluster relation will be chosen as the threshold value. The increasing neighboring nodes does not affect the re- affiliation time. The CR value is based on Total Spatial. Higher the CR, more the mobility will be stability of the node. When the transmission range is increased, more nodes become able to hear each other. The basic clustering strategy is to organize the nodes into a cluster and obtain an organized hierarchical network. The increase in the number of the neighbor nodes will result in the cluster head lifetime improvement. In Lowest- ID algorithm, the number of node whether increased, does not reduce the re- affiliation tomes. Its offers quite a superior performance than that of the MANET algorithms like Max- Degree and Lowest- ID algorithms hence offers better cluster head lifetimes as well as re- affiliation times.

**Rasmeet Singh Bali et. al. [2]** have proposed the concept of intelligent clustering in the VANET which concentrated upon the clustering as well as cluster head selection by the virtue of leadership nodes. VANET itself presents the intelligent features including intelligent vehicles which are capable to go for adaptive decisions for communication between the two parties i.e. the sender and the receiver. The major challenge faced can be the reaching of message to the destination in such peculiar and harsh traffic conditions with constrained mobility parameters. The proposed schemes talks about the learning automata based clustering scheme. The leadership can be attained by relatively a higher degree of connectivity resulting in the formation of a backbone. The leadership nodes register themselves in the race of CH selection. The scheme aims at reducing the clustering overheads and gives a way to the cluster stability. The principle module proposed by the author is the cluster leadership which dependent upon the degree of connectivity. It performs: 1) neighbor sensing, (2)

cluster leadership, (3) CH election. With the reduction in overheads, the node state changes are fewer. It also leads to the overall reduction in the cost because of the presence of lesser nodes for CH election.

**Weijia Li et. al. [3]** proposed an analytical model for studying the performance of MAC protocols which are greatly used in the safety applications for VANET. For safety specific application, the two type of access schemes have been bought into consideration which are random access and cluster based access. Since the robustness is observed in the vehicular networks so the Packet delivery ratio (PDR) and the transmission delay have been highlighted and considered as the responsible factors for it. The algorithm proposed in this model is the Density Threshold Algorithm to make a decision to choose among available two access schemes. When the density of the vehicles see a rise then the performance of random access significantly fades due to the hidden terminals. The mean delay related to the random access channel is quite lesser than the cluster access's s delay. Random access proves itself quite good and efficient in case of low vehicle density in terms of the less delay and acceptable collision probability. Contrarily, the cluster based access performs better in terms of PDR and offers reasonable delays. The scheme further can be implemented for dynamically node switching between the access schemes.

**Mayank Dixit et. al. [4]** presents the various issue encountered in the VANET. Since it have dynamic, multi- hop, unpredictable, unstructured and vehicular scenario, it faces major challenges in these aspects. It has given the descriptive of VANET architecture along with communication architecture- V2V, V2I, V2Broadband, V2Cloud Computing. Various research challenges and VANET characteristics. The research issues are frequent disconnections, delay constraints, power and capacity efficiency, variable network density etc. which can be resolves as the solutions have been suggested by the author.

**Ahizoune et. al. [5]** proposed a stable clustering algorithm based on the affinity propagation majorly concentrates on the parameter of stability. The frequent joining and leaving of the cluster by the nodes can muddle the stability of the network, such disturbance and disorganization can degrade the performance hence resulting in the reduction of overheads. The parameters such as mobility, scalability, leadership, stability are taken into consideration. SBCA uses cluster configuration protocol which is velocity based. For the back- up, it facilitates the use of a secondary CH. The two of the vital phases are the setup phase and maintenance phase where the first phase includes the election of CH and creation of cluster structure and the latter defines the reliability as well as

scalability for the cluster structure obtained from the setup phase. On the note of cluster set up phase, the nodes in the immediate vicinity to each other are organized in a structure of cluster with elected CHs whereas the a secondary CH (SCH) is elected for each cluster in the maintenance phase making the CH in the set up phase as primary CHs (PCH). Reconfiguration is required in case of the cluster is left with no cluster head.

The PCH will take exit from the cluster and SCH will take over its role as a CH performing the duties of PCH and another SCH will come into existence. This algorithm is greatly efficient because if PCH will be no longer available then SCH will take over the whole scenario. It provides an advantage of the extended lifetime of the cluster hence making lager network increases the stability. When the node initially in the undecided state want to join a cluster, it will send the invite to join message to the network node which will perform a check regarding receive signal strength and will forward the request to join message to the neighboring CH including the cluster ID and its address. An ACK will be responded to term the node as a CM and if the node stays in the undecided state for more than a required period of time then it will be the elected CH. The CH is elected on the bases of CH $^{*}$ which is a weight factor: The fundamental aim of the maintenance phase is to utilize two CHs for better stability and reliability. The issue that confers here is of the overheads (OH) because average clustering OH will increase when the nodes will be increased. Also, OH generated in SBCA are lesser than CCP.

**AlMheiri et. al. [6]** presents a survey on MANET and VANET since both are ad- hoc networks so the comparison of their clustering techniques and algorithms can result in wonderful outcomes. It has also discussed need of traffic safety for the Intelligent Transport System which will also enhance the efficiency of the road. The different areas of applications of ITS are road enforcement, animal detection, collision detection, auto driver provisions and many more. As the message is being broadcasted via various nodes in MANETs and VANETs, there also comes some issues and challenges as the hurdle affecting the broadcast. Cluster size according to many algorithms is not of a fixedly sized due to which there can be observed a significant effect on the throughput of a cluster which is decreasing. It leads to the loss of many urgent and important messages like traffic safety message of collision avoidance, which can cost lives. Many algorithms have considered unpredictable assumptions. The simulation tools plays a major role in the gain of information and to calculate and

implement various schemes but some algorithms like MOBIC is only ideal for the low to moderate traffic density and does not serves the purpose for higher density.

**Azizian et. al. [7]** proposed the scheme of distributed D- hop cluster formation clustering is dependent on location service which uses the location as well as the speed movement direction. It provides the study on collective computable parameters like radio transmission, density and connectivity. If considering a 1- hop cluster will provide a smaller coverage whereas a multi- hop cluster will proved to be better in the terms of stability and the reduced maintenance cost will boost the routing efficiency. Modified DMAC easily adapts the VANET environment and avoids the cluster formation if the vehicle directions are opposite. D- Hop cluster is formed using WAVE where the vehicles periodically send the beacon messages. Hence the formed cluster will either be the CH or the D- communication will hop away. The CH will have the least mobility. Also it will choose another vehicle in every next hop. The vehicle chosen as a CH must possess the highest degree among the other vehicular nodes. The three phases of cluster formation are: *Initial Phase, Relative Max, and Maintenance*. A one by one selection of vehicles is able to avoid the issue of congestion by reducing the message exchange on a larger scale. The clusters formed are more stable. A CH change number also plays a critical role in achieving the stability. Lesser the cluster head change number, more will be the stability. The drop in maximum allowed number of hops and the maximum velocity of vehicles will result in the increase of CH change number. Primarily, CH change number of DHCV is lower than VMaSC, due to the individual selection of relative velocity between the CMs while choosing a CH. D- hop enables the significant rise in cluster lifetime hence reducing the cluster number change. Large clusters will elevate the stability in VmaSC but he D- hop algorithm offers stability with small clusters also. Hence, the clusters are more stable in DHCV. As this clustering scheme offers more stability by considering the cluster membership duration and cluster head changes, hence allowing scheduling of wireless networking resources. In comparison with the other multi hop clustering schemes, the proposed algorithm serves for better stability of the cluster by the virtue of cluster membership duration and CH changes.

**Calvo et. al. [8]** proposes a two level cooperative scheme along with the clustering prediction method. Coalition game theory has been conceptualized to bring out its use in the cluster head selection in order to enhance and maintain the stability of the cluster. Clustering nodes possess a dynamic nature which can be predicted with the help of beacons sent by the CH to RSU. For cluster lifetime

enhancement, LTE is used to interconnect the RSU's with each other. It chooses different clustering method as the lowest- ID, utility function, highest degree. In this approach it is needed that the infrastructure should have a control on the nodes. In order to reduce the congestion, the approach has suggested to use less number of beacon messages. This all along

**Cooper et. al. [10]** In active clustering a common channel is used to cluster the nodes for cluster formation and for the maintenance with the other network. Considering a finite channel bandwidth, the active clustering may arise disputes among the clustering and routing traffic due to finite channel bandwidth. Also, there is the requirement of additional overhead to form and reform cluster. Some of the active clustering approaches are weighted metric, precedence and timer based clustering technique. The dispute between clustering and routing traffic can be resolved using the advantageous clustering approach called passive clustering. PC also cooperate with the systems to form the cluster and in this way the vague traffic can be neglected.

**Dwande et. al. [12]** Enhanced distributed multi- hop clustering algorithm for VANETs based on neighborhood follow collaborated with RSU to overcome the problem of uncertainty in replies of the DHCA which leads to packet OH and increase in the selection time for a cluster. This algorithm is beneficial in terms of reduction in overheads by reducing the hello packet Ohs and reduction in the cluster selection timing. As compared to one hop and multi hop algorithms, hello packet was sent to every vehicle but this algorithm is particular because it will contact RSU for obtaining the information about a stable cluster.

**Dhugga et. al. [13]** This gives an insight of various clustering techniques as: (1) Mobile clustering (2) Non- mobile clustering (3) Certificate based clustering. The prime focus of SGCA- efficient vehicular communication in a network OH reduction. Integrity between nodes with authenticity using Centre Servers' database. This proposes the Architecture Design Algorithm for GSC (ADAGS) which has proved itself better than the Location based Multipath Flooding w.r.t packet delivery ratio, packet drop, throughput etc.

**Khalid et. al. [14]** proposed the algorithm where the cluster head is selected on the bases of various matrices such as the relative speed and how distant is the vehicle from neighborhood. This offers a

high stability as well as a better lifetime of the CH. When the cluster maintenance time will increase, it will lead to the decrease in speed as well as future position of the vehicle is less likely to be predicted.

**Malsekar et. al. [17]** Agent based dynamic clustering is for the hybrid VANETs to build a stable dynamic topology and tries to make clusters less dynamic. Cluster formation in this algorithm is started by the roadside unit (RSU) responsible for cluster formation, CH selection where vehicle node constitutes to achieve dynamism. The communication failure issue is quite common which can easily be eliminated by the dynamic clustering. ADCHV performs better for cluster lifetime.

**Rossi et. al. [20]** The issues of robustness and adaptability to the dynamic networks can be conquered [2using stability based algorithms. The bandwidth and power consumption issues can also be resolved by achieving stability using ScalE proposed in this paper. In the clusters of a network, the number of cells that are losing the contact will be reduced by introducing a back- up CH which also promote an efficient way for the maintenance of the cluster structure. As compared to the VmaSC and highest degree algorithm achieves the cluster stability enhancing cluster lifetime.

**Shahwani et. al. [23]** proposed a clustering algorithm which is based on affinity propagation. Vehicle trajectories are used to enhance the cluster head lifetime. The scheme talks about the stability clustering algorithms. Direction based clustering is proposed by following a CH switching algorithm for better stability and density estimation. Furthermore, the stability is achieved by reducing the radio range up to some extent otherwise Ohs are caused.

**Zhang et. al. [29]** The model proposed in this clustering scheme considers that those vehicles can select the cluster of their choice which comes in the overlapping regions. More the number of vehicles will lead to the formation of the super league cluster. As a result of which non- uniformly distributed vehicles in a heavy number can emerge in a cluster. For a cluster head to be prioritized fitter and best, the vehicles taking part are limited. The objective criteria on the bases of characteristics of vehicular network includes Average distance, Survival Gateway time, and Power condition. The time delay can be affected by the average distance between base station and gateway node. Power condition also plays a major role in the CH selection hence signaling to relatively more

power consumptions in CH. The clustering algorithm of our use works by evaluating the fitness of the cluster. Each vehicle will obviously choose a handsome base station in terms of minimum selection function. The algorithm is initialized by obtaining the feature vectors and calculating the corresponding cardinality and extra interested contents and affiliation is done. Markov process is used to define movement of the vehicles. In the clustering scheme, the selection function is used to calculate the fitness of the cluster. The proposed scheme for clustering maximizes the utilization of resources and leads to reduction in balance load and base station load. It promotes user's QoE as well as the CH selection algorithm reflects the real vehicular networks featuring the support of vehicle selfishness and bounded rationality. The algorithm also gives its best in terms of scalability and convergence simultaneously.

**Chiti et. al. [30]** Clustering approach based on coalition game theory makes the use of networking for the purpose of attaining full context awareness of vehicle. This approach focuses on the setting up of cluster as soon as the grouping of vehicles arises in the dynamic network as the network topology is dynamic in nature. Hence it promotes the intra cluster communication and inter cluster communication across various nodes.

**Teshima et. al. [33]** In this scheme of clustering, the autonomous clustering has been used along with Epidemic Routing. The scheme discussed in this paper eliminates the consumption of network resources by configuring a number of clusters in the network. The cluster head that is responsible for the cluster management stores and forward the data packets by following Store-Carry- Forward mechanism. The issue faced by the VANETs was the consumption of network resources due to high overhead in each node and ubiquitous data and control packets in the network. So, a productive way to manage the network nodes is the autonomous configuration which governs the multiple clusters. The cluster comprises of cluster head, cluster members and gateway where every node has been provided with a unique ID. The cluster head of a node is issued a cluster ID. The autonomous clustering scheme is carried out as: (1) Cluster formation (2) cluster management (3) merging clusters (4) division of cluster. The merger of the cluster done by the pseudo code comes into the picture whenever the cluster member (CM) is lesser than L by sending Merge Query Packet (MQP). The cluster merger ends up by assigning the own cluster ID to source node cluster ID. Hence merger completes by the recipient node of MQAP which will set the cluster ID.

**Srinivas et. al. [35]**General approaches for the clustering scheme [35] are *bottom up* and *top down* approaches which stresses upon minimum and maximum values of number of clusters respectively. The can also be *hard* and *soft* clustering approaches which depends on the node association with a cluster. A top down hard clustering scheme has been used in this approach where a CH can be selected by the node when the condition of operation is varying. LEACH scheme is used to select the cluster head. The protocol phases consists of the joining, leaving and a new CH selection. Due to the dynamic network topology, it is quite challenging to choose a best suited CH as a solution to which the coalition game theory approach has been suggested. It has investigated the urban and highway scenarios which depicts that the nodes needed to be clustered nearly equal to the 10% for the practical coverage area values. Highway scenario highlights the reactiveness of the protocol.

**[31]** For a reliable communication in VANETS the paper reviewed has proposed agent based dynamic clustering for hybrid VANET (AHDCV) which facilitate a reliable communication. Dynamic clustering is that technique in which the dynamic topology is made stable in the presence of clusters which are moving along vehicles. The use of agent technology has been done where RSU contains the agent which commence the cluster formation on the bases of communication range of RSU. The CH is selected on the bases of neighbor list and vehicle position. When CH fails, vehicle agent then the vehicle agent replaces the CH. These present agents are responsible to sense the environment to take the required action independently. The scheme has made assumptions that vehicles re moving in the same direction with same mobility. The maintained neighbor list is checked in case there are two or more vehicles close to the center of the cluster so as to choose a fit CH. Vehicle agent achieves dynamism when RSU leaves the cluster after task accomplishment of cluster formation. RIP is accountable for sending the information present in RKB to VAA of all the CHs. The analysis done using this scheme mentions that the communication range is directly proportional to the number of vehicle. More the vehicles more will be the communication range of RSU. Also, if there are more vehicles and high vehicular speed then cluster formation will take more time which will also affect the CH selection time because it will also increase. The challenge is the cluster lifetime because more will be speed of the vehicle lesser will be the cluster lifetime. Using this clustering scheme with ADCHV, there will be better cluster lifetimes for various mobility values. This scheme mitigates the communication failure in VANETs.

**Zaher et. al. [32]** Clustering is a very useful method to resolve the issues such as scalability which affects the latency as well as the stability of the network. To resolve the issues, the techniques using Adaptive Resonance Theory (ART) has been proposed using which mini clusters based on speed (high, medium, low speed) are created in the vehicle's communication range. As VANETs have revolutionized the vehicular technology, smart sensing and IoT have become a part of it. But to adapt with the vehicular environment and to conquer the issue of stability ART is used. ART is used to create the clusters by classifying the inputs to attributes where ART is basically a neural network which is unsupervised in nature. $F_0$ is the layer where input is being fed and $F_1$ is the comparison layer which check for the similarity in attributes, if there is no similarity with the group, then it will result in the creation of a new group. All the input patterns are compared to be placed in the best suited group which happens at $F_2$ layer. The issue that is confronted is the decrease of lifetime with the higher speeds resulting in unstable clusters. However using the suggested technique for clustering, the number of clusters increases up to three times as compared to other algorithms. One of the best reason to use this scheme is the less bandwidth occupancy with the help of mini clusters, packet transfer can be well managed and we can also cope with the dynamicity of VANET environment.

**Zhang et. al.[36 ]** it proposes The processes of CH selection, affiliation and cluster merging also comes into being. In this studied scheme, metrics such as link and node metrics are used to act like various clustering algorithms [36]. Best node metrics are reviewed by this algorithm to choose the CH. First come first serve: This policy is used to tackle the multiple CHs so as to choose the first CH. Best mean: It checks for the best node metrics to assign the CH Best pair: this policy decides for the CH on the bases of link metrics. To achieve the stability of a cluster it is not at all mandatory in this algorithm to incorporate the cluster affiliation and the cluster merger process. Since many of the clustering algorithms focus on the stability of the cluster which can be achieved by considering the performance parameters such as CH and CM duration along with the number of cluster formed. The scheme has considered a safe transmission range threshold R must be greater than the distances to make CH/ CM connections. As per the discussed model of channel propagation model, the models needs not to be particularly fixed, it can vary with respect to roads, vehicles and time. A soft link break is created whenever the distance is greater than R which result in disconnection of CH/CM pair. So, to create a CH/CM connection the distance is required to lie

within the range of R. during cluster formation, no loss of exchanging messages has been assumed so as to mitigate the randomness that can occur due to collision. Whenever all the vehicles will be present on the road, the clustering process will
hence executes at a fixed interval of time. After a certain interval of time, the connection will be ended up.

**Souza et. al. [24]** The studied algorithm proposes a mobility and stability based clustering algorithm (MSCA) which considers the parameters such as traffic flow rate and changing maximum lane speed. This scheme also propose data dissemination along with providing stability. The dire need for this algorithm is a stable cluster with low overheads. The metrics include direction, position and velocity of the vehicle. This is based on V2V communication. GPS is being deployed in all the vehicles so that the position information, velocity and direction of movement where each and every vehicle calculates the relative speed w.r.t the neighbors. The distance to its neighbors can also be obtained.

# CHAPTER-3

# RATIONALE AND SCOPE OF STUDY

## 1.1 Benefits of the Earlier Papers Published

- A cluster is a group of nodes that can communicate with each other and can transfer the information through a connection established between them. Each cluster has a cluster head whose purpose is to co-ordinate the communication among the nodes present in the cluster. Since the network environment in VANETs does not follow a specific fashion, hence clustering is required which can be implemented with the help of various clustering algorithms in accordance with the required metrics.
- It presents an easy way for faster data dissemination and message delivering which contributes greatly for accident avoidance by providing prior information to the driver.
- Cluster Head selection mechanism with the help of clustering algorithms like dynamic clustering, dual clustering, back up CH selection or intelligent clustering etc. constitute their eminent efforts in choosing suitable and efficient CH. Somehow the clustering structure heads as a challenge in such a dynamic environment of VANET where the dire need is to pick up a potential CH by calculating its fitness via algorithms.
- Various techniques have been developed in the recent years for the clustering of vehicular nodes but stability of the cluster is still a major concern. The clusters may integrate with other clusters if needed because other nodes may leave the cluster so if one node is left then it may join other cluster as a cluster member. Hence the increased lifetime of cluster, cluster head and cluster members can enhance the stability for maintaining a predictable performance.
- In earlier researches, papers are considerably focused on the security issues, energy and storage capacity in the network, density based algorithms, and comparison of algorithm with MANET but it is required to primarily focus on intelligent clustering. The key issue faced in the VANET is that work on design analysis and clustering algorithm is least touched as compared to clustering in most of the published work of researchers.
- VANETs present a largest real time application but lacks security, scalability, efficient

routing and clustering protocols. The significant aim of the study to stress upon the clustering and to propose efficient cluster head selection algorithm.

- The study carried out will focus on clustering for choosing a stable cluster head in mobile network for ‘n’ number of hopes. Since mobility and stability are considered as the vital parameters for proposed work so the comparison with pre-existing techniques will be performed for proving the efficiency of the algorithm.

## 1.2 Scope of the study

Clustering in vehicular ad- hoc networks have its sole hand in dividing the various groups of vehicles according to a specific set of rules. For every cluster, a leader is required which is termed as a cluster head whose function is application specific. A cluster head acts as a mediator between the cluster and network. It provides the opportunity to reduce transmission overheads in V2V communication, also provides the provision of back up cluster in the absence of the cluster head till the time new cluster head is not elected. It also provides the advantage to dynamically set the parameters and provision of wireless resource saving is also dispensed.

According to its operational area, the concept of clustering has scope of study as follows:

- It can be used in VANET for channel access management
- Dynamic clustering can be used for mobility and stability of a cluster
- Greatly be brought into common usage for traffic safety hence giving instructions to drivers regarding collision avoidance or need of co- operative driver (auto driving).
- It can provide way out for the management of frequent disconnections, hidden node problems, mobility prediction with the clustering of the vehicles.

# Chapter-4

# Objective of the Study

The formulated objectives of the proposed work are as follows:

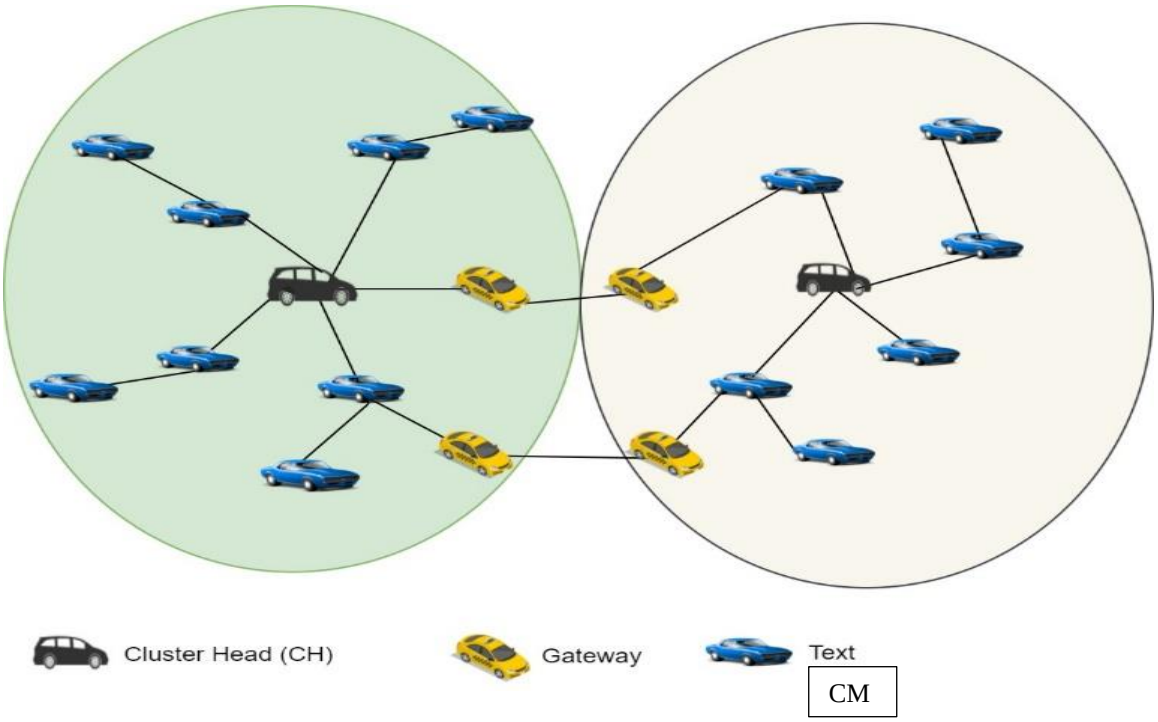
1. To compare the clustering algorithms to draw out the efficient clustering algorithm
2. To implement dynamic clustering in VANETs and CH selection
3. To study the impact of number of hopes on cluster performance with n- hops
4. To improve cluster performance using target tracking algorithm

# CHAPTER- 5

# RESEARCH METHODOLOGY

## 5.1 System model

In our system model, the clustering is on the bases of stability and mobility based clustering. We will be adopting the clustering algorithm shown in figure 5.1 for choosing a CH and the CM among the neighboring nodes. It performs gateway node selection cluster head selection and cluster member selection. In a vehicular ad- hoc networks, the various vehicular nodes are mobile and the neighborhood discovery begins on the note to incorporate members in the clusters for efficient transfer of information. When the node enters a network, it marks its presence through a broadcast message and results in a neighborhood table. A suitable cluster head is chosen and the affiliation is granted. If a suitable CH is not obtained then the members of the clusters are continuously monitored. If we lose all the cluster members due to the dynamicity of the network then the process will restart by re- accessing the neighbors.




CM< L= merger with one of the neighboring cluster
CM> U= cluster divided into two cluster by CM

Figure 5.1 Cluster Formation

The number of hops to the cluster members from the cluster heads can be determined as single- hop or multi- hop where maximum of the clustering algorithms employ the single- hop clusters in which the distance between CM and CH is just one hop where it is easy to reduce or mitigate the issue of packet loss where the vehicle is made aware of the one hop away vehicle information. The state diagram depicting state change will be:

TABLE- III Node Description

| **Nodes** | **Description** |
|---|---|
| UN | • Vehicle belongs to none of the cluster<br>• Initial state of the vehicles |
| CH | • Cluster leader communications with members in its cluster<br>• One CH (primary) in one cluster at a time |
| CM | • One- hop neighbour of CH<br>• Nodes in the cluster that communicate with CH<br>• Performs inter cluster communication<br>• Member nodes also assigned as gateways which are located at the edge of the cluster (GW) |
| $CH_t$ | • Temporary cluster head<br>• Mitigated after CH is finally elected |

*Neighborhood discovery* stands for the discovery of the nodes in a vehicular network to form the cluster. Initially the willing node will enter the network and to be a part of the vehicular network. Then the announcement of availability will be made by the broadcasting of periodic message being active or passive clustering. A database is prepared where the information regarding the neighboring nodes is stored.

*Cluster Head Selection* is choosing a leader among all. The fittest of all wins the race to be a leader termed as a cluster head. When all the data is gathered in the database then the CH is chosen on the bases of various parameters like mobility matrices, speed, velocity, relative distance etc. the cluster members are affiliated. Affiliation will be awarded to the CM and CH.

*Announcement* is done to know about the neighbors and affiliation process.

*Maintenance* allows the maintenance process for the cluster heads as well as cluster members. Where

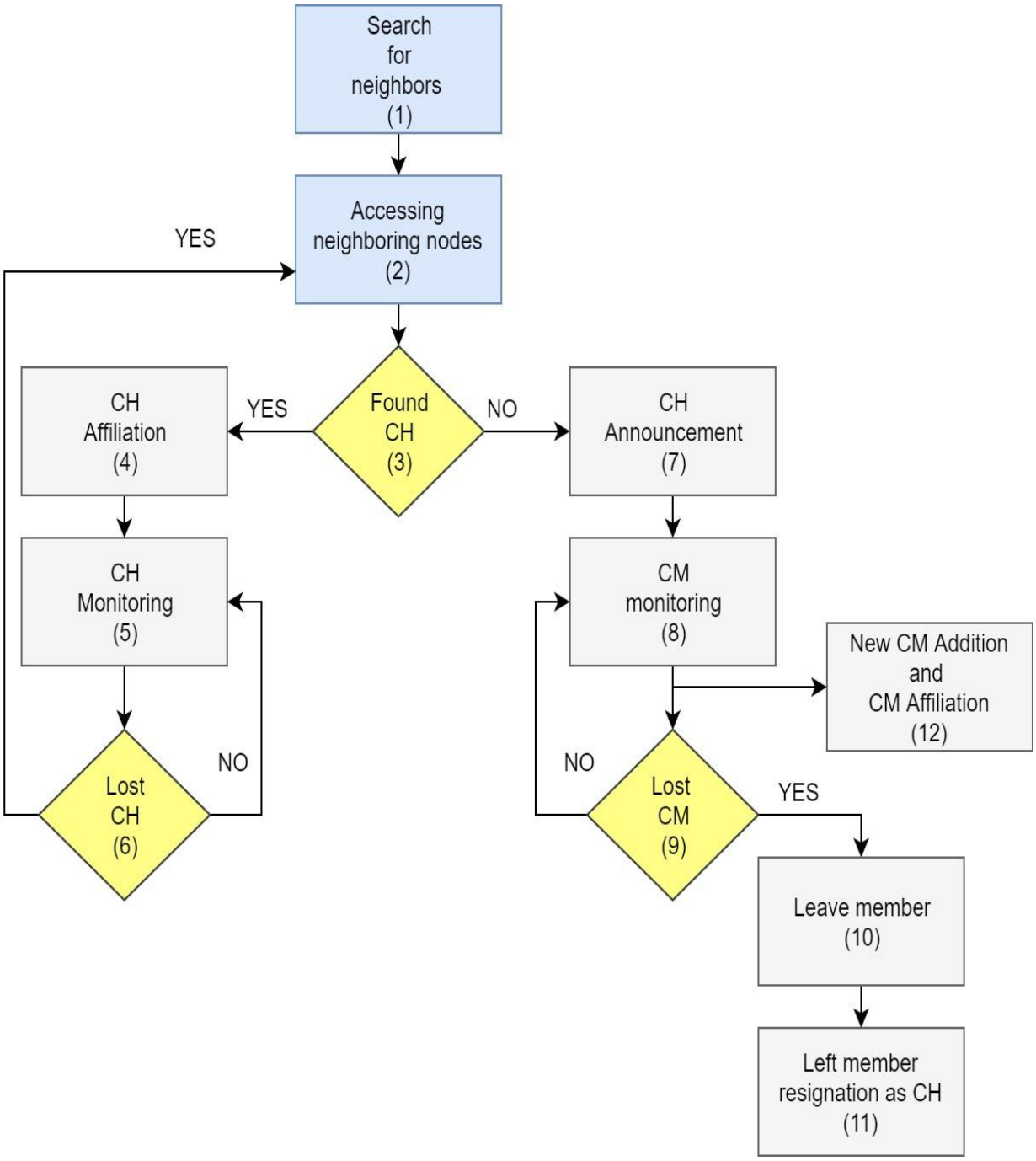



**Figure 5.2 General Algorithm in VANETS for ClusteringS**

it enables the cluster head to manage a cluster and merging of the cluster and still maintains the network clusters. The nodes also periodically look for the links with the associated CH. The strongest CM can be turned out to a CH in case no CH is present.

Some parameters have been considered prior to the implementation of the schemes which provides a platform for better outcome and are necessary to be considered:

| Parameters | Values |
|---|---|
| Simulation time | 300s |
| MAC Protocol | IEEE 802.11p |
| TR | 200m |
| Number of vehicles | 100m |
| Road length | 15 Km |
| Car length | 5m |
| Acceleration rate | 2.6 $m/s^2$ |
| De- acceleration rate | 4.5 $m/s^2$ |
| Maximum lane speed (MLS) | 10- 40 m/s |
| Traffic flow rate | 1200 vehicles per hour |
| $D_t$ | 100- 200 m |
| BI | 1.0 s |
| MI | 10.0 s |
| $T_{ub}$ | 5.0 s |
| Propagation model | Two- Ray Ground |
| Number of iterations | 10 |
| Mobility model | Car- following model |

# CHAPTER- 6

# RESULTS AND DISCUSSIONS

As per the observations from vehicular ad- hoc networks, the less number of clusters are organized where the value of $D_t$ is relatively kept high. In reference with the ETSC standards, the CAM messages are particularly broadcasted considering the frequency range between 1 to 10nHz. The initial default value of Beacon interval will be taken and set to 1.0 s and for future implementation and resultsit will be increased from a range of 0.5 to 2.0 or further in order to obtain ideal results while simulation.

**Tools:**

- SUMO
- NS2
- MATLAB

The results showcased in fig. 6.1 represents the average cluster head duration with the total percentage of time. When the $D_t$ is increases, there can be observed a slight change in the cluster head duration and maintains the stability.

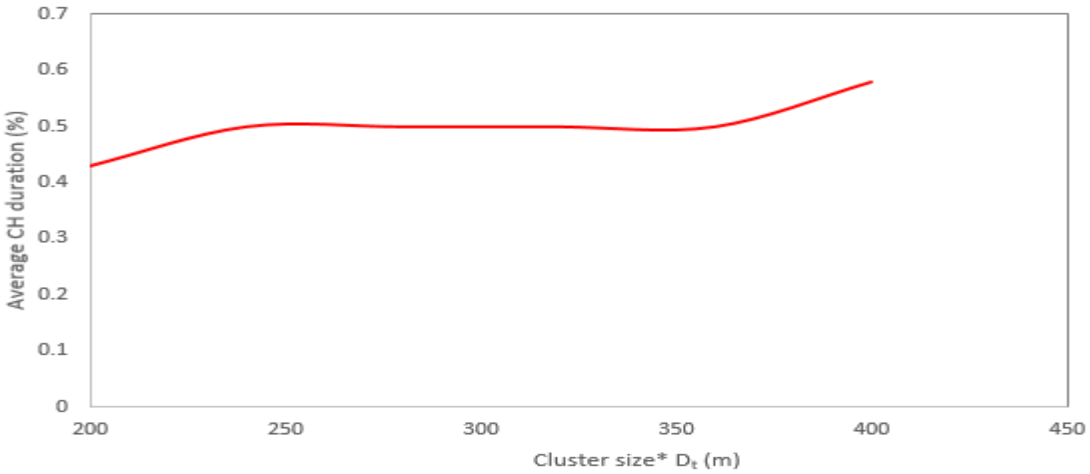



**Figure 6.1 Average CH duration**

The resulted showcased in the figure 6.2, represents the Cluster member average duration where there is a significant increase in the size of the cluster. Also it is observable that $D_t$ has a tiny impact on both the nodes whether it is cluster head or cluster member. Average CM duration is considered on the y- label the cluster size on the x- axis which specifies that the significant decrease is observed when the cluster member duration is increased.

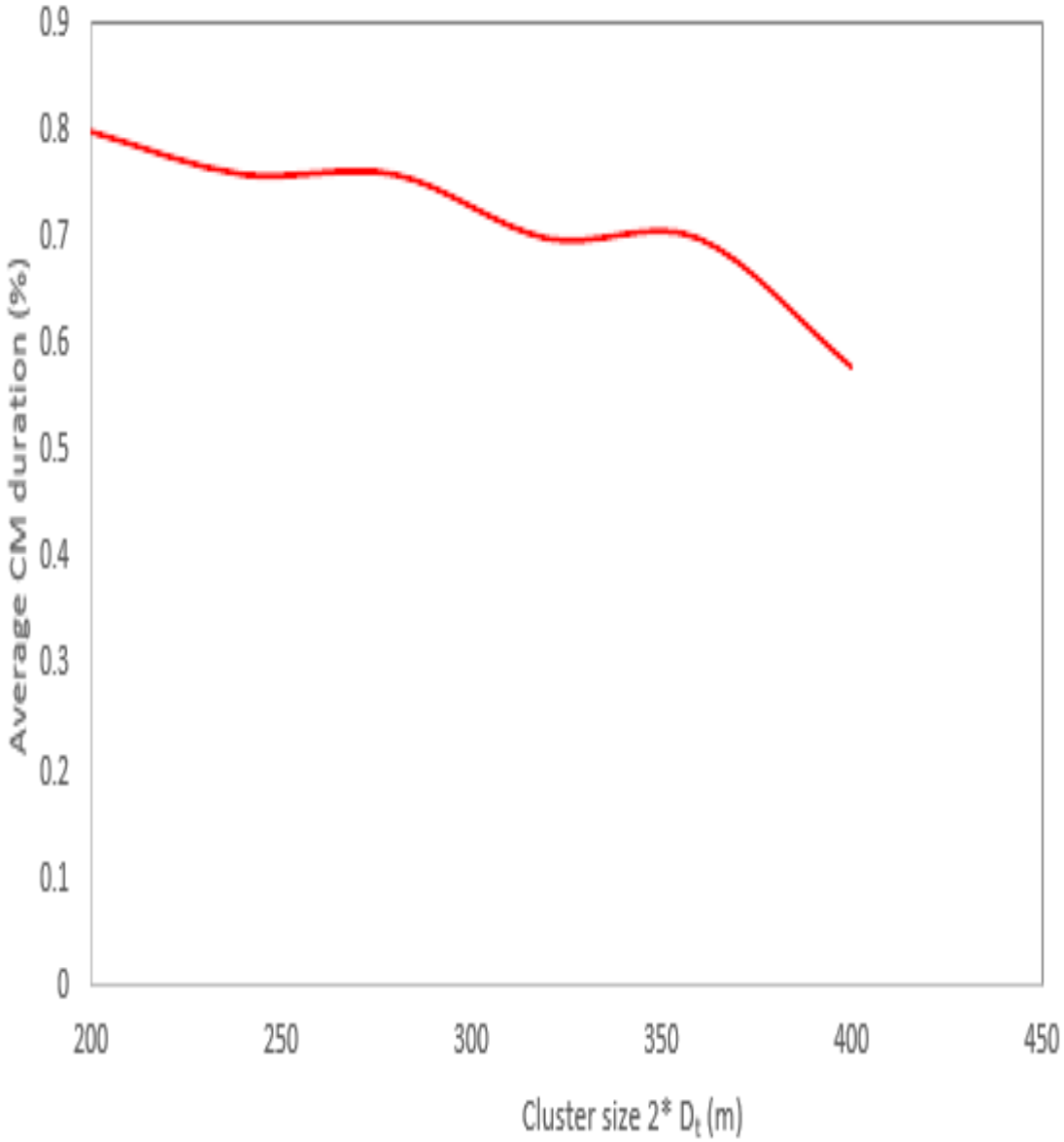



**Figure 6.2 Average CM duration**

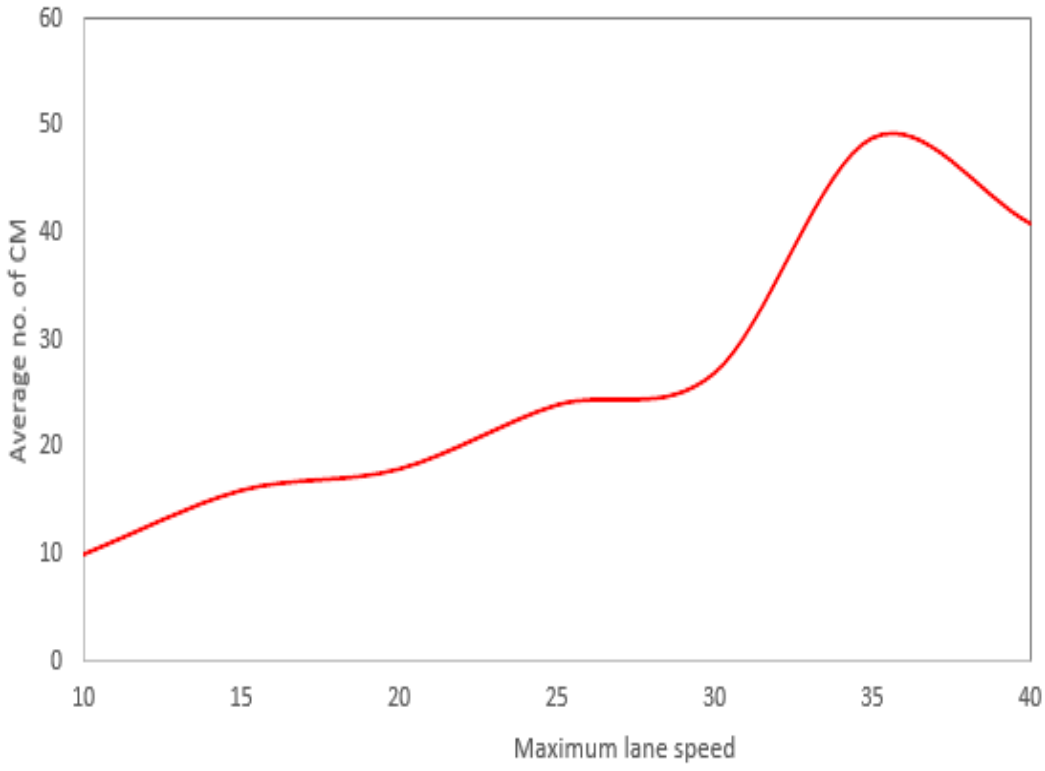



**Figure 6.3 (a) average number for UN for VMaSC**

The number of clusters heads and the undecided nodes in comparison with the VMaSC has been depicted in figure 6.3 (a) and (b). When the value of MLS is significantly made to rise up then the UN states of the cluster also changes in VMaSC for only 1- hop between the CMs and the cluster head.

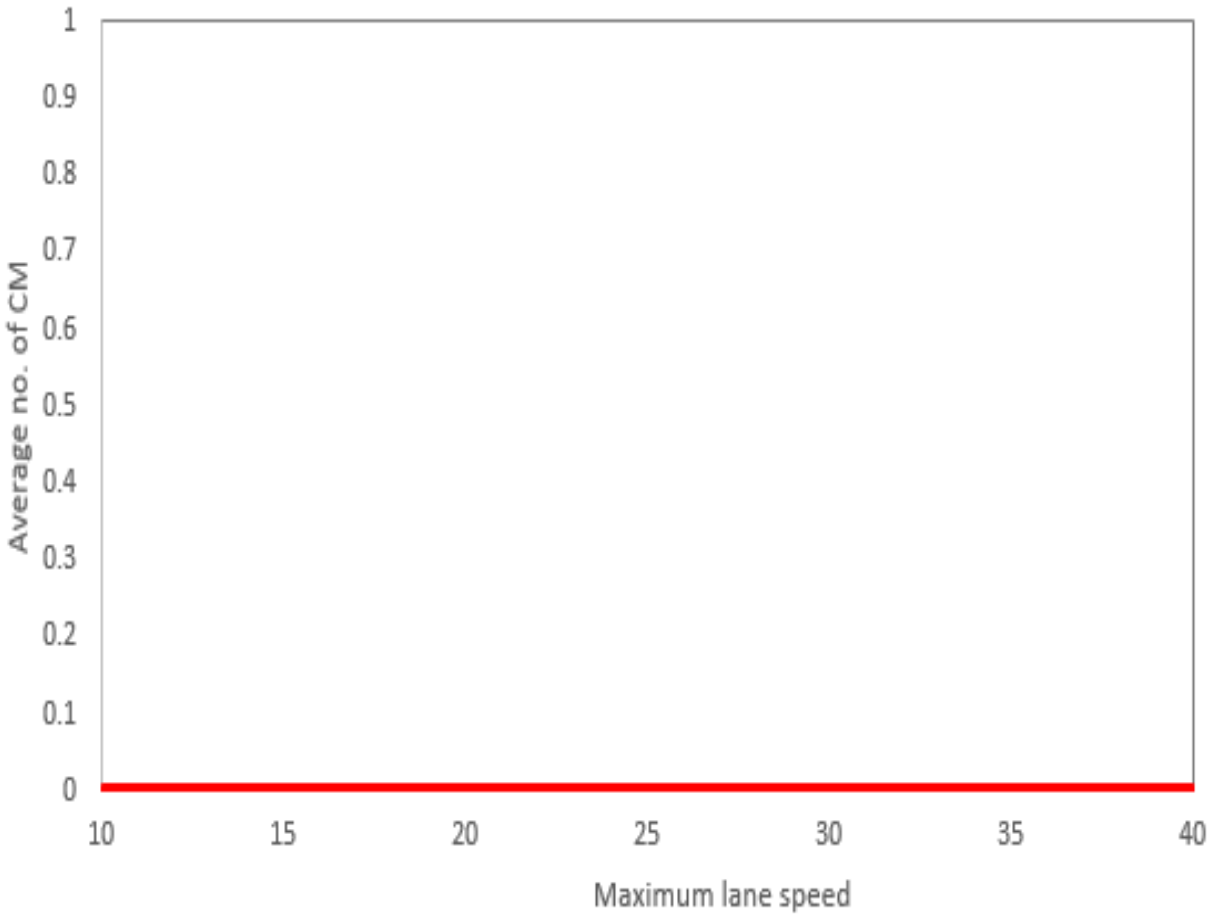



**Figure 6.4 Average number of UN for 1- hop scheme**

# CHAPTER- 7

# CONCLUSION AND FUTURE SCOPE

In the work carried out till date has primarily focused on the study of various clustering techniques and algorithms out of which one techniques has been formulated to implement dynamic clustering with n number of hops while considering the two parameters of mobility and stability. The analysis are describing the status of Clustering Algorithm. The implemented clustering scheme has been compared with the VMaSC. The simulation tool is NS2 and the test scenario to be further considered is the highway scenario where traffic will also be generated with the help of SUMO (Simulation of Urban Mobility). The performance matrices calculated are average cluster head duration, average CM duration and the comparison of average number of Undecided node for VMaSC and 1- hop average number.

**Future Scope**

- We can improve the stability of the cluster using dynamic clustering
- To use clustering for efficient CH selection and back- up cluster head
- To improve efficiency in network using increased hops.

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