A Stable Clustering Architecture for Efficient Routing and Resource Allocation in Vehicular Ad Hoc Networks

Mousumi Ahmed Mimi
012193036

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This thesis titled "**A Stable Clustering Architecture for Efficient Routing and Resource Allocation in Vehicular Ad Hoc Networks**" submitted by **Mousumi Ahmed Mimi**, ID: **012193036** has been credited as adequate in accomplishment of the demand for the degree of Master of Science in Computer Science and Engineering on December 2021.

Board of Examiners

1.

______________________________ Supervisor

Mohammed Mamun Elahi
Assistant Professor
Department of Computer Science and Engineering
United International University
Dhaka, Bangladesh

2.

______________________________ Head Examiner

Prof. Dr. Salekul Islam
Professor& Head of the Dept.
Department of Computer Science and Engineering
United International University
Dhaka, Bangladesh

3.

______________________________ Examiner-I

Prof. Dr. A. K. M. Muzahidul Islam
Professor
Department of Computer Science and Engineering
United International University
Dhaka, Bangladesh

4.

______________________________ Examiner-II

Prof. Dr. Md. Motaharul Islam
Professor
Department of Computer Science and Engineering
United International University
Dhaka, Bangladesh

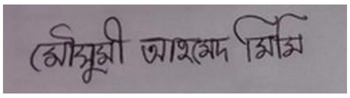
5.

______________________________ Ex-Officio

Prof. Dr. Mohammed Nurul Huda
Professor & Director-MSCSE Program
Department of Computer Science and Engineering
United International University
Dhaka, Bangladesh

Declaration

This is to confirm that the work accredit "**A Stable Clustering Architecture for Efficient Routing and Resource Allocation in Vehicular Ad Hoc Networks**" is the research work done by me under the supervision of Mohammed Mamun Elahi.



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Mousumi Ahmed Mimi
012193036
Master of Science in Computer Science and Engineering
United International University
Dhaka,Bangladesh

In my capacity as supervisor of the candidate's thesis, I certify that the above statements are true to the best of my knowledge.

____

Mohammed Mamun Elahi
Assistant Professor
Department of Computer Science and Engineering
United International University
Dhaka, Bangladesh

Abstract

Vehicular Ad hoc Network (VANET) is an area of wireless networks, which makes connections among vehicles to enable vehicle to vehicle or vehicle to infrastructure communication and supports diversified applications related to road safety, data transfer, offloading resources etc. Although significant efforts have been made since the last few decades, there are still a huge number of research problems to be solved in VANET. Link stability is one of them. To make link stable, many researchers have applied single-hop and multi-hop clustering approaches to make links stable to increase connectivity time. In this work, we have used the idea of a multi-hop clustering that makes links more stable. We have applied the idea of forwarding node that connects one cluster to other clusters through cluster head resulting higher link stability.

We have also extended our work to utilize the developed cluster architecture for resource allocation, which is another important area of research for vehicular applications. We applied the idea of multi-hop clustering with the forwarding node to make the link stable and minimize the time for allocating the resource and minimize the time to calculate when a node moves from one cluster to another cluster. Extended simulation has been done using SUMO and NS3 to compare the proposed clustering algorithm with other similar approaches in the literature. The results show the efficacy of our proposed algorithm in terms of different performance parameters.

Acknowledgment

I am very grateful to Allah for the successful completion of my thesis. My unreserved acknowledgment, heartfelt liability, and huge acclaim go to my supervisor, Mohammed Mamun Elahi, Assistant Professor, Department of Computer Science and Engineering, United International University for his sustained administration, unselfish counsel, and considerable motivation and cheering. His eager delight in the topic and treasures study of counsel all over the study were of great succor in finished. Ultimately, I am very grateful to thank my ammu for her significant abetment, forbearance, and advice during the course of my thesis.

Publications

1. M. A. Mimi and M. M. Elahi, "A Stable Clustering Architecture for Efficient Routing in Vehicular Ad Hoc Networks," *2021 International Conference on Automation, Control and Mechatronics for Industry 4.0 (ACMI)*, 2021, pp. 1-6, doi: 10.1109/ACMI53878.2021.9528093.
2. M. A. Mimi and M. M. Elahi, "Using Multi-Hop Clustering for Computation Offloading in Collaborative Vehicular Ad Hoc Networks," *submitted*.

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Chapter 1

Introduction

Vehicular Ad hoc Network (VANET) is an active area of research under wireless networks, which makes connections among vehicles to enable vehicle to vehicle or vehicle to infrastructure communication and supports diversified applications related to road safety, data transfer, offloading resources etc. VANET provides ITS(Intelligent Transport System), road safety, automatic driving, communication, data passing[1][2]. Common problems in VANET are link unstable, high velocity of vehicles, less cache memory, resource offloading problem, can't offload resource, because of moving vehicle problem for offloading resource, packet loss etc. [3][4]. Although significant efforts have been made since the last few decades, there are still a huge number of research problems to be solved in VANET. Link stability is one of them. To make link stable, many researchers have applied single-hop and multi-hop clustering approaches to make links stable to increase connectivity time. There are other challenges like resource offloading, dynamic velocity, moving vehicles, dynamic network topology, path duration, cluster formation and maintenance, resource allocation, memory allocation, cache problem [5].

Among the research areas in VANET link stability and resource allocation is two one of the popular research sub topic. To make link stable a lot of researchers work on a lot of algorithms. There is both single hop and multi-hop algorithms. Among single-hop algorithm there are OLSR, AODV, DSR, DSDV. All of this algorithm work on the road scenario with the RSU architecture. They consider about the single hop and if the CM move outside from the hop so the RSU will make the coverage and transfer the data packet. But if there is no RSU coverage so next that isolate node will do what and how that isolate node will get the data they does not consider. So it is a major problem in single hop clustering. So solve this major problem the researchers apply multi-hop clustering idea and PMC, N-HOP, VMaSC, DMHNCF are the developed multi-hop clustering algorithm. Through the multi-hop clustering algorithm there make the connection between one hop to another hop. So when a CM transfer from one cluster to another cluster at that time because of connection the data can transfer from source to destination. To make the connection between one cluster to another cluster some researchers apply age node, some researchers apply FN. The age node or the FN transfer the message from source to destination. But here the problem is if any CM become isolate and it can't find any road side unit coverage area so what will happen at that time. Even the CH is the major node so it's very important to get the high sustainable vehicle as CH. But problem in their research is they figure out that border node become the CH but the problem is that all the vehicles are moving so fast so it is a huge problem if the border node become the CH. So we apply a stable clustering architecture that will give the coverage and figure out which vehicle will become the CH.

1.1. Motivation

Link sustainability [6] provides a valuable ideal in research area for VANET. In VANET there is no network topology as vehicles are moving continuously, there is no static network topology, and there is dynamic network topology. So make link stable is very difficult. So make link stable is very challenging [12]. To make link stable researchers apply single hop clustering and multi-hop clustering algorithms. But there are lots of problem for both single-hop clustering and multi-hop clustering which make to link stable much more challengeable. For that reason we apply a new proposed architecture for making link stable with the use of idea of multi-hop clustering architecture.[7][8].

The world is developed because of science. Many researchers develop new research ideas to upgrade our world. There are a lot of research topics such as IoT, Machine learning, Networking, Software, Data mining, AI, etc. . Wireless sensor network is part of networking and VANET is a sub-part of wireless networks. VANET means Vehicular Ad-Hoc Networks. VANET makes connections among vehicle to vehicle or vehicle to infrastructure. VANET makes road safety, transfer data, offload resources. There are a huge number of research areas in VANET. VANET provides ITS(Intelligent Transport System), road safety, automatic driving, communication, data passing[1][2]. Though we get a lot of opportunities from VANET but there are a lot of problems and from those problems we actually find our thesis topic and we want to upgrade those problems. Common problems in VANET are link unstable, high velocity of vehicles, less cache memory, resource offloading problem, can't offload resource, because of moving vehicle problem for offloading resource, packet loss etc. [3][4]. There are huge challenge like link stability, resource offloading, dynamic velocity, moving vehicles, dynamic network topology, link stability, path duration, cluster formation and maintenance, resource allocation, memory allocation, cache problem [5].

Another challenge in VANET is resource allocation and offloading. Because of high mobility resource offloading is very difficult from one vehicle to another vehicle. Offloading resources is a great challenge while vehicles mobility is not static, but slow mobility vehicles have some computational tasks, where the vehicle's direction is not stable[22]. With the use of fixed Road Side Units (RSUs), task offloading can be done from one vehicle to another vehicle. But without the coverage of RSU, it is not possible to offload the computational tasks. Clustering may be a good approach to offload computational units particularly in a Vehicle-to-Vehicle (V2V) scenario, where fixed infrastructure is absent. For offloading computational tasks, most of the researchers use RSU, cloud, and a single-vehicle. For resource management, it gets the set of resource blocks of radio (RB) and levels of power for vehicle to vehicle and vehicle to infrastructure users [23]. Vehicle to vehicle can apply two different applications: those are the allocated method and the reuse method, V2V gives same resources as the cellular user and keep allocated resources separately [23].

There are a lot of challenges and problems in VANET [10]. Some problems are[24]:

- Stoppage (If the source node and destination node is very far away not possible to transfer data packet.)
- Awful achievement because of continuous break up.
- Demolition of bandwidth because of accident of packets
- Caching issue because of less of intermediate storage
- Unstable or unpredictable links .

1.2 Context and Background

The world is developed because of science. Many researchers develop new research ideas to upgrade our world. There are a lot of research topics such as IoT, Machine learning, Networking, Software, Data mining, AI, etc. . Wireless sensor network is part of networking and VANET is a sub-part of wireless networks. VANET means Vehicular Ad-Hoc Networks. VANET makes connections among vehicle to vehicle or vehicle to infrastructure. VANET makes road safety, transfer data, offload resources. There are a huge number of research areas in VANET. VANET provides ITS(Intelligent Transport System), road safety, automatic driving, communication, data passing[1][2]. Though we get a lot of opportunities from VANET but there are a lot of problems and from those problems we actually find our thesis topic and we want to upgrade those problems. Common problems in VANET are link unstable, high velocity of vehicles, less cache memory, resource offloading problem, can't offload resource, because of moving vehicle problem for offloading resource, packet loss etc. [3][4]. There are huge challenge like link stability, resource offloading, dynamic velocity, moving vehicles, dynamic network topology, link stability, path duration, cluster formation and maintenance, resource allocation, memory allocation, cache problem [5].

The units of VANET architecture that is given in figure 1 which is RSU (Unit for Road Side), OBU (Unit for On Board) and AU (Unit for Application) [9]. OBU , RSU, AU all of them are connected with each other.OBU provides the V2V communication. Through the OBU the data pass from one vehicle to another vehicle. Application Unit provides the information about vehicles. RSU make the connection between vehicles to infrastructure. RSU can be as intelligent traffic light or it can be base station. Through the OBU data pass from one vehicle to another vehicle. OBU make the car intelligent. If there is a car without OBU so it can't connect with RSU or other vehicle.

Link stability depends on various parameters. Among them velocity of vehicle, number of hops, number of nodes, position of vehicles, path duration, architecture of the road scenario, road length, density of vehicle. Among them path duration is straight corresponding to link stability. Path duration depends on velocity of vehicles, cluster number, and transmission range of the vehicle. [12].

If the node that is represent the source and the node that is represent the destination under the equal hop at that time it take minimum time to transfer data packet. But if the source node and destination node are very far away at that point of time it's very difficult and challenging to transfer data packet form source to destination. [10]. By using single hop clustering algorithm it's not possible to transfer the packet from source to destination. But the use of idea of multi hop clustering it's easy to transfer data packet from source to destination. [13][14][15].

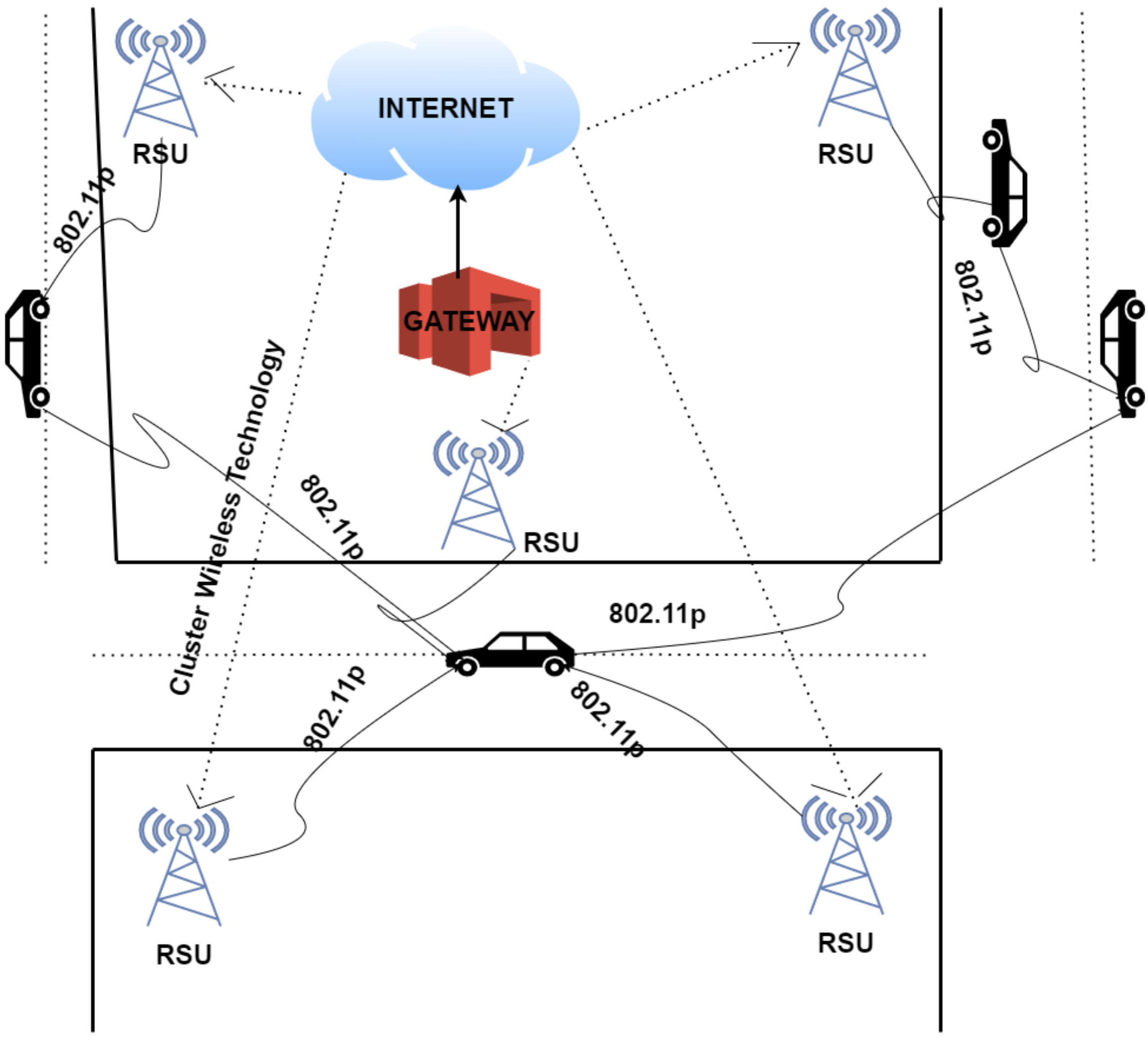

Figure 1: Typical VANET architecture [9]

There are a lot of challenges and problems in VANET [10]. Some problems are [24]:

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- Awful achievement because of continuous break up.
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1.3 Objectives and Contribution

In our research paper we study about link stability and resource allocation. From study all the research papers we find out to make link stable researchers work on both single hop clustering and multi hop clustering algorithms. If the source node and destination node under same cluster so at that time single hop clustering is enough for transferring data packet from the node which is source to the node which is destination. But if the node which is source ; the node which is destination are far away at that time multi-hop clustering algorithm is needed for make link stable. For our thesis we choose multi-hop clustering algorithm for make link stable. For making link stable we provide a proposed algorithm that have CH (Cluster head), CM(Cluster member), FN(Forwarding Node). This FN actually makes the connection between one CH to another CH. With the help of this FN the data packet can be transfer from the node that is source to the node that is destination if the source node and destination nodes is far away.

The proposed clustering architecture is also used for resource allocation in vehicular networks. Extending the idea of the paper[24], we have used multi-hop clustering for resource sharing in a V2V scenario. Using the forwarding node (FN) as the anchor node, one CH can be connected with other CHs as shown in figure 2.

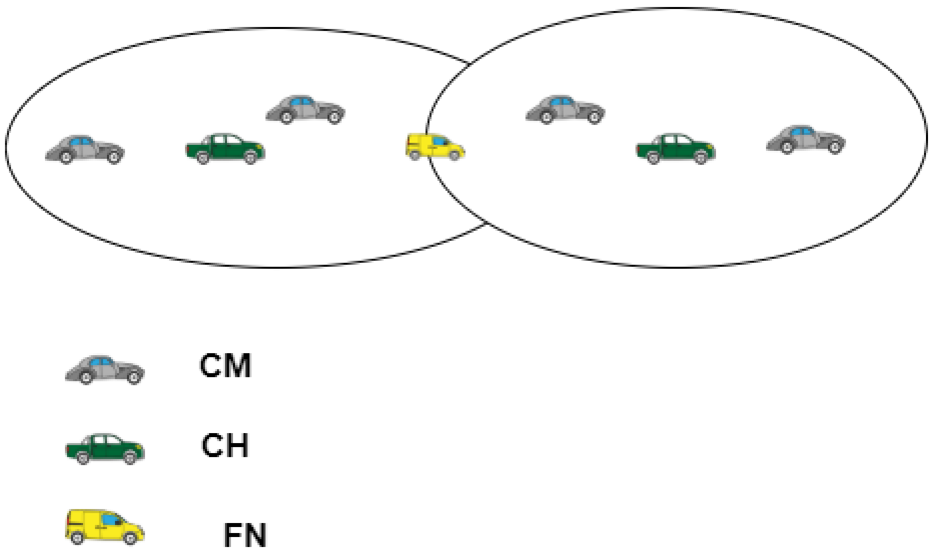

Figure 2: Cluster formation where FN is under the range both cluster 1 and cluster 2

1.4 Organization of the Thesis

The report is organized as follows: Chapter 2 discusses background and literature review about link stability and resource allocation. Chapter 3 describes the methodology and the proposed system architecture. Chapter 4 illustrates the simulation results. Finally, chapter 5 gives the concluding remarks and directions towards some future works.

Chapter 2

Background and Literature Review

2.1 Definition of terms

For this research, we use some terms as CH (Cluster Head), CM (Cluster Member), FN(Forwarding Node) for link stability and cloud layer, edge-layer, hop-layer with the idea of link stability we also use it for resource allocation.

CH: It is the major node in a cluster that helps to make the link stable and decide the root for transferring packets from sender to receiver.

CM: It is the member node of a cluster that is connected with the cluster head and if the sender and receiver are at the same cluster this CM will transfer the packet from sender to receiver.

FN: It is another CM. The CM which connected more than one CH at that point that node becomes the FN. For our research, FN is one of the most important nodes for transferring a packet from source to destination. If the sender and receiver are in different clusters at that time FN will help to make connections from one cluster to another cluster. This FN will transfer the message from one CH to another CH.

Cloud Layer: In this layer contains the database of the vehicle information about the vehicle direction, road length, velocity, the value of computational resources. This will store the long-term data.

Edge-Layer: Network architecture can be found in this layer. Where there will be RSU/ Base Station/ Intelligent Traffic Light which will connect to the hop layer and cloud layer. Edge-layer gets the information from the cloud layer and transfers that information to the top layer.

Hop-Layer: In this layer, there will be vehicles that will form multi-hop clustering. There will be CH, CM, and FN. This FN will help to connect from one cluster to another cluster.

2.2 Problems of Routing in VANETs Take Advantage of Link Stability and Resource Allocation

One challenging issue of vehicular Ad-Hoc Network is link sustainability. To make link we apply our proposed architecture for multi-hop clustering algorithm. For our thesis we make the calculation to select the most stable CH as the CH is the major node to make link stable. So for make link stable the first thing that it need to figure out the best sustainability node to become the cluster head (CH). Then the second major node is the FN that make the connection between one CH to another CH. The CM that is connected with more than one CH that CM become the FN. There are a lot of network topology as data fusion, clustering, hybrid, topology, geography etc. [10]. Transferring message from the node that is source to the node that is destination we have to use the network topology. For our thesis we apply clustering architecture for transferring data packet from source to destination.

For link stability problem occurs in resource allocation. As the link is not stable so if a vehicle wants to offload its resource to another vehicle and if that vehicle becomes out of range within a second at that time resource offloading can't happen correctly. So for that purpose to make a link stable we follow our previous research paper architecture[24] where we provide a detailed description of the procedure to make a link stable. When the link is stable, resource allocation will be done properly. There will be limited time within that limited time one vehicle can offload its computational task to another vehicle and through the OBU it's possible to find out every vehicle information such as their velocity, mobility, road length, the time that the vehicle will stay in that range, etc.

2.3 Parameters Connected to Link Stability

Path duration is chief parameters connected to link stability. The vehicles that have lofty velocity make a big problem in road timing which is actually duration of the path and duration of the link. In [12], the authors communicated inter connection amidst parameters that link sustainability hang on road timing means the duration of the path, duration of the link, clusters number, velocity of the vehicles, and density of the vehicles.

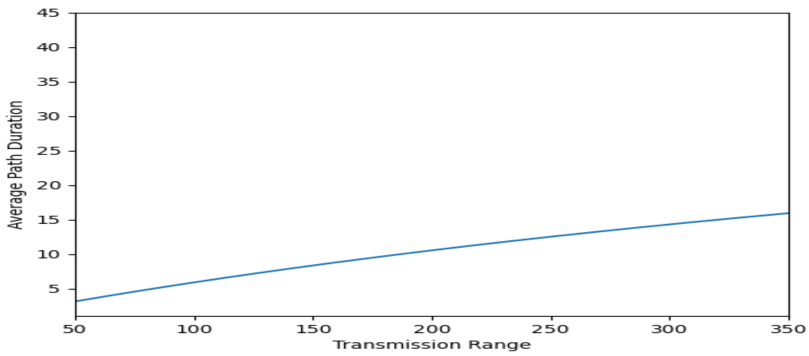

Figure3:.Average road timing (duration of path) is straightly corrosponding to the range of the transmission [12]

For our thesis our applicable few mathematical simulations. So for mathematical simulation we use Python. To reveal the upshot of dissimilar framework on the evaluation of road timing (Path Duration) depend on link sustainability. Architecture of the road scenario developed with a assorted how many vehicles are there, various variables (transmission range (m), clusters number or hops number, and vehicles velocity (m/s)) are anyway select and an mean worth have been lay hold on for 30 runs of every case. Given at the Figure 3, 4, 5, transmission range is straightly corresponding to the average road timing (duration of path), cluster number , vehicle velocity is un-straightly corresponding to average road timing mean the duration of path.[12]

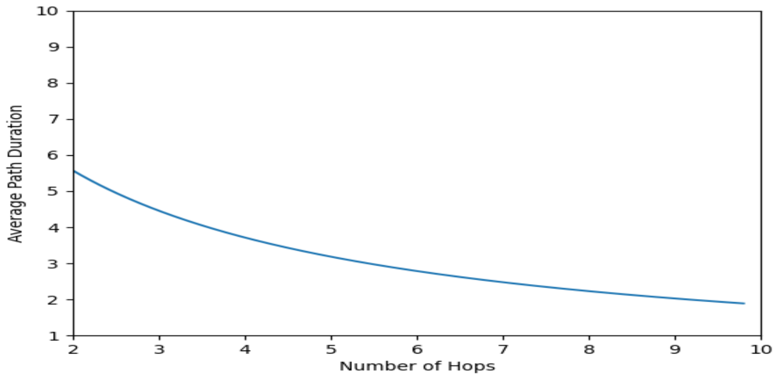

Figure 4: Average road timing (duration of path)(m/s) is un-straightly corresponding to cluster number(number of hops). [12]

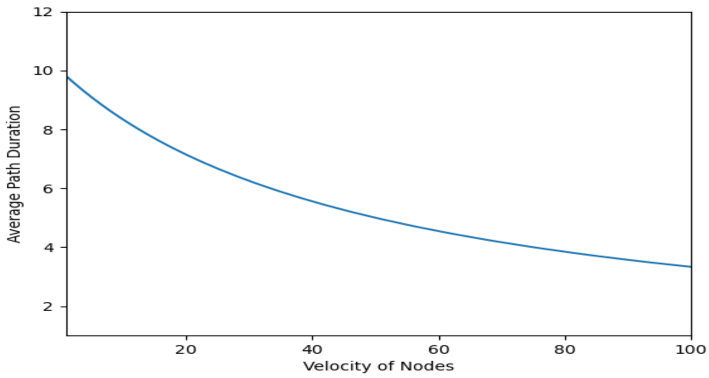

Figure 5. Velocity of vehicles are indirectly proportional to avegare path duration .[12]

Elevated vehicles velocity, elevated hazard is the link will smashed. Among expanded the cluster number for passing message between the vehicle which is source to the vehicle which is destination that expanded possibility under links among the link duration. Thinking related mobility among the vehicles with the regulation of motion can assist to forecast the link sustainability for upgraded road riming, which will edit routing performance.

The standard payload of BSM is 39 bytes. The computational resources can be cache size, bandwidth, and frequency of CPU [22]. For resource allocation, the parameters we need are link duration, path duration, velocity, road length, available computational unit, etc. Among them, link duration is one of the most important parameters. As vehicles on the road are high mobility and velocity so it's difficult to offload the computational task. As the vehicles are not stable so it's difficult to offload the computational unit. In[12], the researchers have shown the relationship that link stability depends on path duration. From paper [24], we have shown an architecture to make links stable and with that architecture, we can make links stable and vehicles can offload computational units to the available vehicles those vehicles are in the same range.

2.4Related Works

In[1],the researchers provides that latest unsegregated technologies have swap many live fields and changed into latest and updated data communication way such as, smart traffic system, smart cars, smart electronic devices, and smart music systems. In this research paper researchers apply IoT base VANET which named as IoV. With the help of IoT base VANET where researchers try to apply to work with VANET with IoT. With SDN they apply to work with VANET. But in there research they don’t provide any algorithm to make link stable with real life scenario.

In paper[2], the researchers use the idea of edge layer where it works as like as clustering. But here the researchers do not provide any clear idea that how one edge layer will connect to another edge layer.

In paper [3], the researchers use the idea of a single hop with a cellular station for resource allocation but if the CM gets out of the range of the same cluster sohow that CM will get the resource or offload the resources.

In paper[4], the researchers use 3 layers as cloud layer, edge layer, and user layer. They use the idea about the master node and slave node. Where the master node will select which node will offload the computational task and which slave node will take the resource. In this paper, researchers do not clear about how the edge layer and edge node will work and also how in the user layer, it will select the master node and slave node. There is no clear idea that which way the user layer will select the master node and slave node.

In the paper [5], the researchers discuss two-tier down-link heterogeneous UDN where it also uses single clustering and with the help of a cellular station. UDN (Ultra-Dens-Networks) improved the network throughput and energy efficiency.

In paper [6], the researchers work on single-hop clustering for resource allocation where they use the idea of cellular. This cellular will work as like as BS or RSU. The CH will connect this cellular station and the CM will connect to the CH. But the problem in this paper is that if CM go out from the range of CH how CH will allocate resource.

In [7], the researchers work for VANET with the idea of Software Define Network (SDN). With this software they make a road architecture for V2I. They apply that every road architecture RSU. The problem in their research is that they don't think about what will happen if there is no RSU or the vehicle move out from RSU so how the data will be pass from V2I architecture.

In[8],the researchers provides that latest unsegregated technologies have swap many live fields and changed into latest and updated data communication way such as, smart traffic system, smart cars, smart electronic devices, and smart music systems. In this research paper researchers apply IoT base VANET which named as IoV. With the help of IoT base VANET where researchers try to apply to work with VANET with IoT. With SDN they apply to work with VANET. But in there research they don't provide any algorithm to make link stable with real life scenario.

In paper[9], the researchers use 3 layers as cloud layer, edge layer, and user layer. They use the idea about the master node and slave node. Where the master node will select which node will offload the computational task and which slave node will take the resource. In this paper, researchers do not clear about how the edge layer and edge node will work and also how in the user layer, it will select the master node and slave node. There is no clear idea that which way the user layer will select the master node and slave node.

In [10], the researchers work on single hop architecture for VANET scenario. The major problem of the single hop architecture is that if the source and destination node are not in the same hop so at that time how the node pass data from source to destination.

Authors in [11] proposed a clustering architecture for weighted clustering for software define network. It consider there is intelligent traffic light system work as RSU which transfer data packet to CH and CH transfer data packet from source to destination. The problem of this research paper is that if there is no available RSU so at that point of time how CH get the message and data packet.

In [12], the researchers study on N-Hop clustering architecture that apply the multi-hop clustering. The major problem of their research is that to find out CH and CM is take too time and through their research their the not clarity that they select the most stable CH. AS they can’t find out the stable CH so the changing of CH is again and again makes interrupt.

In paper [13], the researchers work on RSU and BS as intelligent traffic system for providing V2I connection. They apply the idea to transfer data packet from source to destination. But the problem of their paper is if there is no RSU coverage at that time how the data packet will transfer from source to destination. The researchers does not show any way if there is no RSU coverage. So here the problem is occur.

In paper [14] the researchers work on link stability with the use of intelligent traffic light as RSU and they make relationship between VANET and IoT. Through the idea of IoT base they try to make road scenario with the idea of VANET. But they do not classify which type of network protocol they will be use or which type of network topology they will use. They even discuss about the problem for link stability.

In paper [15] the researchers work on AODV where they consider always the vehicle follow star topology as the major node will be the CH and other nodes will be the CM. Data will transfer from CH to CM. Even they think that the cluster will be so close with each other so from one CH and another CH can be connected. They don’t think if one cluster become isolated at that time what will happen and if there is no RSU coverage so how the isolate cluster can be connected with another cluster head. They basically work on single-hop clustering. So in their research there are a lot of problems occur in their research.

In [16], the researchers provide a new multi-hop clustering architecture to make link stable. Here researchers figure out the highest sustainability node as to make CH as the cluster head is the major node to make link stable. But they only calculate the node that is connected maximum number of nodes but the problem is they don't calculate the staying time of the CH.

In [17], the researchers proposed a stable clustering architecture for D2D network where it shows to make the CH more stable but here the problem is the researchers don't follow for large network topology it only apply for the small network topology where it not applicable for large network.

Authors in [18] researchers apply the effective selection of the cluster head (ECHS) architecture to get the best accurate cluster head. Their idea for selecting the CH is the most important node which apply the CH selection scheme to make link stable but the problem is that they not calculate if the CH move outside from that time it takes a lot of time to calculate new CH.

In[19],the authors have provided the idea of continuous path direction changes happened by the high speed of vehicles and network overload caused by safety messages to transfer from source to destination to the high way road scenario. The proposed scenario apply only for highway road architecture but it does not provide any road structure for high density of vehicles. This scenario is only applied for small network architecture but it can't apply for the large network architecture.

Authors in [20] proposed a clustering architecture for weighted clustering for software define network. It consider there is intelligent traffic light system work as RSU which transfer data packet to CH and CH transfer data packet from source to destination. The problem of this research paper is that if there is no available RSU so at that point of time how CH get the message and data packet.

In paper[22], the researchers use 3 layers as cloud layer, edge layer, and user layer. They use the idea about the master node and slave node. Where the master node will select which node will offload the computational task and which slave node will take the resource. In this paper, researchers do not clear about how the edge layer and edge node will work and also how in the user layer, it will select the master node and slave node. There is no clear idea that which way the user layer will select the master node and slave node.

In paper [23], the researchers work on single-hop clustering for resource allocation where they use the idea of cellular. This cellular will work as like as BS or RSU. The CH will connect this cellular station and the CM will connect to the CH. But the problem in this paper is that if CM go out from the range of CH how CH will allocate resource.

In paper[24], we discuss multi-hop clustering where the FN makes the connection among the CH. So with the formula of multi-hop clustering, it makes link stable and in this research paper we use that formula to make link stable and it will be easy to find out which CM will be able to allocate the resource and which CM will offload the resource.

In the paper [25], the researchers discuss two-tier down-link heterogeneous UDN where it also uses single clustering and with the help of a cellular station. UDN (Ultra-Dens-Networks) improved the network throughput and energy efficiency.

From the study, we can find out many types of resource allocation systems. Where maximum papers use the idea of the cellular station and also use the idea of single-hop clustering. The cellular station will provide the information to the CH and the CH will find out which CM will be able to allocate resources and which CM will offload the resources. In paper [22] researchers use the same idea of the cellular station and also provide the idea of a master node and slave node. The master node will transfer the computational unit to the slave node. Here some research questions occur those are:

- If there is no cellular station coverage now how CM will offload the resource.
- If there is no RSU coverage or the RSU coverage is available but the RSU is not working. So how CM and CH will offload the resource to CM.
- In paper[22], the researchers use the idea of edge layer where it works as like as clustering. But here the researchers do not provide any clear idea that how one edge layer will connect to another edge layer.

- In paper [23], the researchers use the idea of a single hop with a cellular station for resource allocation but if the CM gets out of the range of the same cluster so how that CM will get the resource or offload the resources.
- So from all of the research papers, the common question is how the information will pass from one CH to another CH if there is no RSU of the cellular station.

For solving these research questions in this paper we provide the idea of paper [24], where we have used link stability for multi-hop clustering. We have extended the multi-hop clustering architecture to decide how the CH will figure out which CM needs to offload and allocate resources efficiently.

So according to all of these research papers, some of them work on the single hop, some of them work for multi-hop, we target to work with multi-hop clustering as it is much more efficient than single-hop clustering. Among the multi-hop clustering algorithms, we try to make our algorithm much more effective than other multi-hop clustering algorithms. For that purpose, we developed the idea and do the mathematical calculation with our researcher architecture which discussed details in chapter 3. Also, we develop another idea for resource allocation with the help of the idea of our proposed algorithm architecture. This also discusses details in chapter 3

2.5 Thesis and Research Questions with Summary

From the study, we establish that countless formulas were applied to dragoon the link sustainability as applying last corner node as it also called the node name as border node, applying hop as single topology ; hop as a multi topology clustering; applying position solutions. Nevertheless in no way about labour hinge applicable directed build a link much sustainable before applying as a choice evaluate significant variables this one lastly apply to the road timing (duration of the path). Our intention is develop the link sustainable by applying an flexible link sustainability algorithm the thing indicated firmly forecast link sustainability applying a clustering algorithm that is based on multiple hop cluster. In our thesis and research the architecture we applied as, cluster head, cluster member and forwarding node . Previously all the researchers work with the idea where there will be RSU but in our research we apply FN which helps to connect one cluster to another cluster. We assume that if there is no RSU coverage scenario at that point of time what will happen and for solve that major issue we apply the idea of FN and through the FN the data transfer from one cluster to another cluster.

For a supple mathematical stapes to forecast link sustainability as a vehicle can apply the duration of the link for flexible connection among nodes, few investigation inquiries are arrived here. At first need to find out ideal cluster head through obtainable nodes or vehicles or road side unit? According to the proposed mathematical structure nodes as cluster head, finding the appropriate piece isn't minor on account lofty velocity. Furthermore, another query is arrived as forecast link sustainability from one cluster to another cluster? This in go round will delegate vehicle to forecast the duration of the path become assist for upgrading recovered connection production and narrow obstruct or packet loss, thus raise final dispatch.

From the study, we can find out many types of resource allocation systems. Where maximum papers use the idea of the cellular station and also use the idea of single-hop clustering. The cellular station will provide the information to the CH and the CH will find out which CM will be able to allocate resources and which CM will offload the resources. In paper [22] researchers use the same idea of the cellular station and also provide the idea of a master node and slave node. The master node will transfer the computational unit to the slave node. Here some research questions occur those are:

- If there is no cellular station coverage now how CM will offload the resource.
- If there is no RSU coverage or the RSU coverage is available but the RSU is not working. So how CM and CH will offload the resource to CM.
- In paper[22], the researchers use the idea of edge layer where it works as like as clustering. But here the researchers do not provide any clear idea that how one edge layer will connect to another edge layer.

- In paper [23], the researchers use the idea of a single hop with a cellular station for resource allocation but if the CM gets out of the range of the same cluster so how that CM will get the resource or offload the resources.
- So from all of the research papers, the common question is how the information will pass from one CH to another CH if there is no RSU of the cellular station.

For solving these research questions in this paper we provide the idea of paper [24], where we have used link stability for multi-hop clustering. We have extended the multi-hop clustering architecture to decide how the CH will figure out which CM needs to offload and allocate resources efficiently.

Chapter 3

Methodology

3.1 System Overview for Link Stability

From all the research papers what we find out that some work with RSU scenario as intelligent traffic light work as RSU. Researchers work on V2I. Where the CH get the message from RSU. Then the CH transfer the data from source to destination. If the vehicle that is work as the node as named as source and the vehicle that is called the node which is destination are in the identical cluster so the cluster head transfer the packet from source to destination. When the source node and destination nodes are far away at that time through RSU the message transfer to the CH and the CH will transfer the message to source node and somehow the destination node get the message. When it is about same cluster at that time there is no problem. But when it is in different cluster we show in our thesis that how from one cluster to another cluster the data pass from source node to destination node. We apply in our thesis the idea of FN that helps to make the connection between one clusters to another cluster. So with the help of FN it transfers the data/ message from source to destination. If the source node and destination node under the same cluster that time we don’t need FN. The problem is occur when there is no RSU and the node that is source and the node that is destination far away. So at that moment it transfers the message from the vehicle which is source to the vehicle which is destination with the help of FN. So in our these there are 2 major nodes. CH and FN.As CH make the cluster and the link stability depends on most time on CH. So it’s major to figure out the most sustainable vehicle as CH. Otherwise it need to calculate again to figure out the CH. Our proposed architecture provides the most stable CH that will change minimum time. Another major node is FN; the node is connected more than one cluster head. FN is actually CM. CH naturally transfer the message from source to destination. CH connected to CM and FN. CM can’t transfer the message it only get the message. FN transfer the message from one CH to another CH. So when the source node and destination node from the different cluster so from FN the message/ data packet pass from CH to FN and FN transfer to another CH that it connected to.

In our thesis our proposed architecture is given bellow in figure 6. For our research architecture we does not consider RSU. We apply our proposed multi-hop clustering idea. For our architecture we use CH, CM and FN. Among of them our major node for this architecture is CH. Our second major node is FN. According to this figure there are total 6 clusters and each of the cluster are connected with each other through the FN. According to this scenario the green color represents the CH, ash color car represents the CM and yellow color car represents the FN. Orange color car represents the destination node and violate color car represents the source node. According to figure 6 it represents number 6,3,10,12,19,15 are represents the CH. Number 7,8,4,1,2,21,20,13,17,16 are represents CM. Number 5,28, 18,11,14 are representing FN. Here number 2 represents the source node and number 13 represents the destination node. For transferring message from source to destination first node 2 transfer the message to CH3. CH3 checks whether there is the destination node here or not. AS destination node is not under CH3 so CH3 transfer the message to FN28. FN28 transfer the message to CH10. CH10 check whether the destination node are there or not. AS the Destination node is not under CH10 so CH10 transfer message to FN18. FN18 transfer the message to CH 19,CH12. Both of the CH check whether there is the destination node are there or not. As under CH12 so CH12 transfer the message to the destination node 13. This is how our architecture will work according to the road scenario. For our research we apply our proposed algorithm to figure out the most sustainable vehicle as cluster head. The major node FN works to make connection to the one cluster to another cluster. Actually FN is CM. The CM that is related with numerous CH it become the node that is called forwarding as FN.

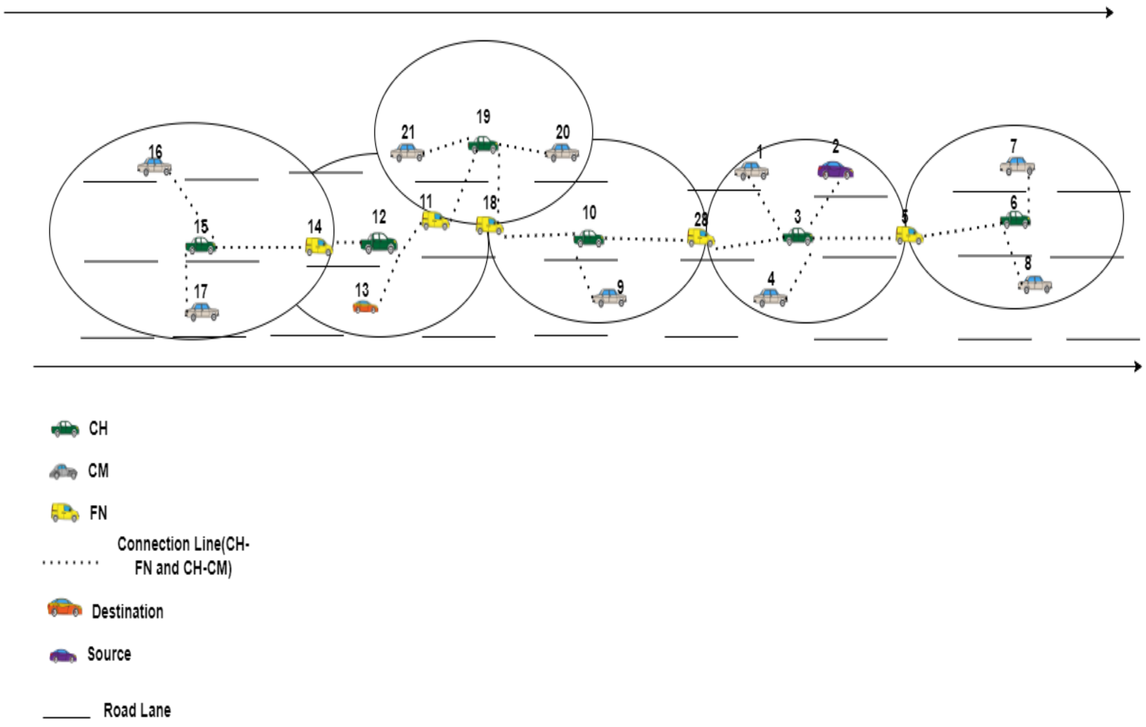

Figure 6.Our proposed and applied clustering diagram.

Every node as vehicle have intelligent vehicle as they have OBU. So each vehicle follow an information table for transferring message and through the OBU the vehicle get the information about who is the CH, CM and FN. Also through the OBU the vehicles can connect with each other. For our architecture we apply OBU in the vehicles for road scenario architecture.

3.2 Cluster Formation

For our proposed architecture the major nodes are CH and FN. So for this purpose the major node is the CH. So First of all it need to find out the CH. To find out the CH first it do the priority calculation and from there it find out the CH. After find out CH; CH transfer the Baccon Message to the other vehicles that are surrounding towards it. After sending the message the vehicles which get Baccon Packet send the Acknowledge message to the CH. This way the CH get the knowledge which vehicles are connected with CH. By this way it creates the cluster formation. Every cluster there must be a CH and if a CM isolates that CM become the CH. Every cluster there must be one CH and other will be the cluster member. As our proposed architecture it follows multi-hop clustering so there is another node which is FN. FN makes the connection between one CH to another CH. So with the help of FN the message transfer from one CH to another CH.

3.3 Custer Head Selection

The major node for our research is the CH. So first it needs to be selecting the CH. For selection the CH it needs to get the best sustainable node as the cluster head (CH). If we can't select the most stable node as CH so our link can't be stable as like as previous research. When we go through the previous research we find out that they choose the border node as CH. Those border node are not stable according to our proposed architecture. Even the maximum time of staying under the same cluster is also very important to make the most stable CH. Because if we get the best sustainable node a CH so that time the changed of the CH will be very less and at that time it can make stable cluster. Our major focus to get the best sustainable node as CH. If CH changed its state again and again at that time it need to calculate and need to make cluster formation again. So for selecting the most stable node as CH we need to make some mathematical calculation. Among them we need to do priority calculation. For priority calculation we need to find out the node following degree and the mobility information. According to figure 7, it shows the way to calculate the node following degree. Node following degree is represented by $\boldsymbol{N_{follow}}$. We use equation1:

$$\boldsymbol{N_{follow} = N_{lane} + N_{connect}} \qquad (1)$$

Where $\boldsymbol{N_{lane}}$ represents the total number of vehicles that are follow the CH from the same lane and also can be connected to the CH through the OBU with the help of ACK message that is represents that according to figure 6. $\boldsymbol{N_{connect}}$ represents the vehicles that follow to the CH from the different side of the road according to figure 6. So our first target to find out that vehicle that is followed by maximum number of vehicles and it will store that vehicle information. To become a CH it is very important to find out that specific node that is followed by the maximum number of vehicles.

Another important unit for calculating priority for finding the CH is the mobility.

Mobility represents that how much time the car will stay at the road side . It's very important to stay at the road side maximum time to become CH. If we select a CH that will change instantly at that point of time link will be unstable and CH will change again and again. For that reason find out the vehicle that will stay maximum time it's road architecture it will become the CH. To calculate mobility information it need to calculate velocity of the vehicle which is represent by $\boldsymbol{v}$ To calculate the mobility information it need road length that is represent by $\boldsymbol{rl}$.

For find out mobility information the formula we apply that is given bellow:

$$\boldsymbol{t_{range} = rl/v} \quad (2)$$

Algorithm 3.3.2 show the way to calculate mobility information.

So imagine that in OBU it whole the all vehicle information. SO from the information table that is hold by OBU will collect the value of node following degree and mobility information At last, we find out the priority which is given in the 3.3.2 algorithm using equation 3:

$$\boldsymbol{Priority = a(1/N_{follow}) + (b * t_{range})} \quad (3)$$

3.3.1 Algorithm for Node Following Degree Calculation:

1. $\boldsymbol{START}$
2. $From\ information\ table\ find\ out\ total\ number\ of\ node\ from\ the\ same\ lane$
3. $From\ information\ table\ Find\ out\ total\ number\ of\ node\ from\ the\ different\ lane$
4. $Calculate\ node\ follow\ degree$
5. $\boldsymbol{END}$

.

Here the total weight for $\boldsymbol{a}$and$\boldsymbol{b}$ is1$(\boldsymbol{a+b=1})$. According to the proposed algorithm for calculating the priority we select we apply node following degree and mobility calculation. The unit of node following degree and mobility calculation are different . That's why we take the constant that is $(\boldsymbol{a+b=1})$. This is the way we calculate the priority and find out the CH which is the most stable node in the cluster and the node that is followed by maximum number of CM.

3.3.2 Algorithm for Mobility Calculation:

1. $\boldsymbol{START}$
2. $Calculate\ \ Mobi\_info\ using\ r\_l\ and\ v$
3. $Find\ out\ the\ node\ which\ have\ maximum\ mobility.$
4. $\boldsymbol{END}$

3.3.3.Algorithm for Priority Calculation

1. $\boldsymbol{START}$
2. $Calculate\ N\_follow\ using\ \ N\_lane\ and\ N\_Connected$
3. $Find\ out\ the\ maximum\ value\ for\ N\_follow$
4. $Node\_degree\ value\ will\ be\ the\ maximum\ value\ of\ \ N\_follow$
5. $Calculate\ \ Mobi\_info\ using\ r\_l\ and\ v$
6. $Find\ out\ the\ node\ which\ have\ maximum\ mobility.$
7. $Calculate\ Priority\ value\ using\ maximum\ mobility\ and\ \ \ Node\_degree$
8. $Find\ out\ the\ maximum\ Priority\ of\ \ Node$
9. $The\ maximum\ Priority\ node\ will\ become\ the\ CH$
10. $\boldsymbol{END}$

3.4 Forwarding Node (FN) Selection

Algorithm no 3.4.1 explains the way to figure out FN. FN plays a major role in our work. As the CM is connected to more than one CH that will become the FN. With the help of FN, it is possible to make a connection between one hop to another hop. FN transfers hello packet pass from source to destination. In figure 6 we have already shown the way to packet pass from source to destination.

3.4.1. Algorithm for FN Calculation and CM Calculation

1. $\boldsymbol{START}$

2. $Find\ out\ CH$
3. $\boldsymbol{IF}\ \ NODE\ connected\ with\ CH$
4. $Start\ Count$
5. $\boldsymbol{IF}\ \ that\ NODE\ connected\ with\ more\ than\ one\ CH$
6. $NODE\ become\ FN$
7. $\boldsymbol{End\ of\ IF}$
8. $\boldsymbol{ELSE}\ \ that\ NODE\ become\ CM$
9. $\boldsymbol{END\ of\ ELSE}$
10. $\boldsymbol{END\ of\ IF}$
11. $\boldsymbol{END}$

3.5 Proposed Algorithm

Here figure 8 is represented the proposed algorithm's flow chart,that is shown the stapes from here we can figure out the CH, FN, and CM. In the proposed algorithm CH and FN is the most important state. This FN makes the link sustainable in our research.

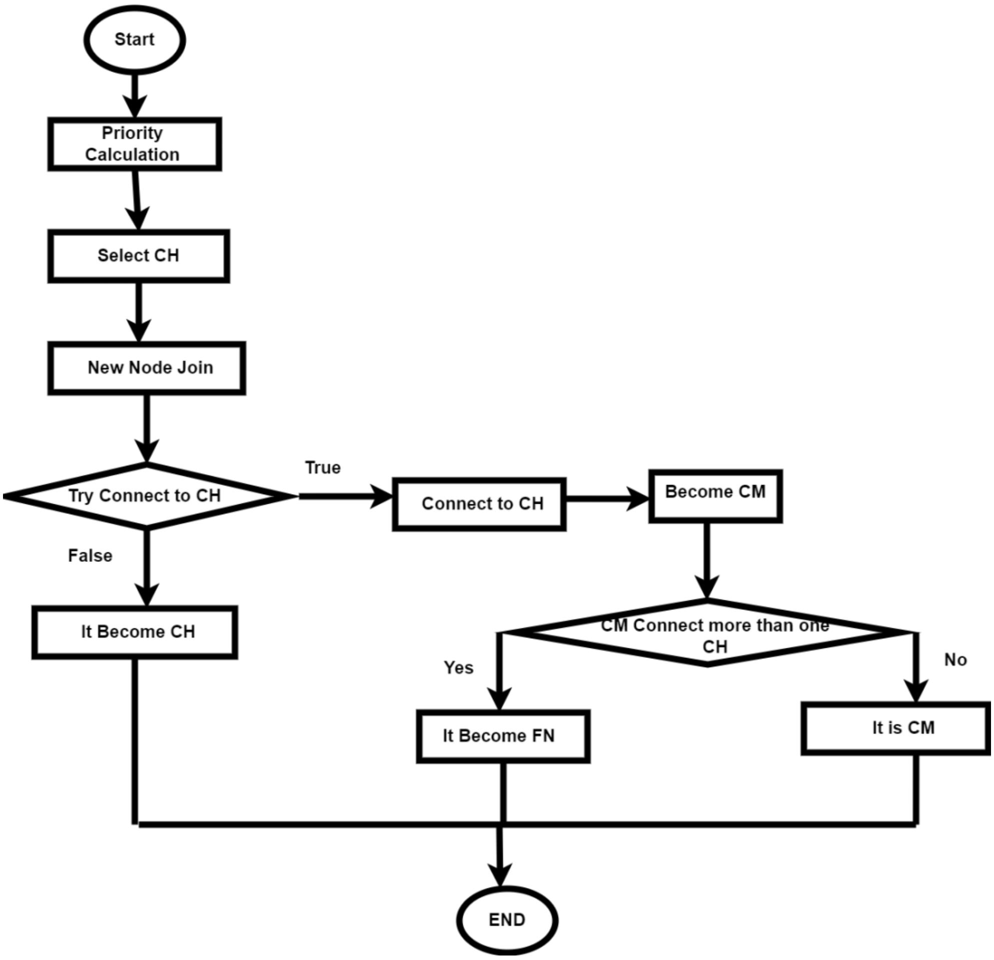

Figure 7.Flowchart of the proposed algorithm for finding out the CM,CH;FN

3.5.1. State Definition

Every vehicle must have a state in multi-hop clustering architecture. The vehicle changes its state in the multi-hop clustering by using its state. The states of the proposed algorithm are:

1) CH: Cluster head that helps to make a connection between one to another hop.

2) CM: Cluster member helps to transfer the data from source to destination if the source and destination are under the same CH.

3) FN: FN is another major node for maintain cluster that actually make connection from one cluster to another cluster. Actually the vehicle that is related with more than one hops it become FN. According to figure 6 we see the node that is connected more than one CH it actually become the FN. Actually FN helps to make connect one cluster to another

cluster. From the algorithm it shows the relationship among the clusters. When the source and destination vehicles are apart from each other. So with the help of FN it transfer the message from source to destination.

3.5.2. Information Table Create and Edit According to Time

In VANET, a neighbor table called Information Table is held and maintained in each vehicle, it has its vehicle information and also figures out the neighbor nodes within the maximum hop(MAX_HOP) range.

Table 1. Information Table

Vehicle_ID
Vehicle_State
Vehicle_Location
Vehicle_Velocity
Road_Length
CH_ID
CM_ID
Number of followers from the same lane
Number of followers from different land
Mobility information=road_Length/velocity
FN_ID
Time State
Node Range

This information table has vehicle _ID, vehicle_state as whether it is on moving or sleeping, vehicle _Location which represents which area the vehicle is, Vehicle_Velocity, road_length according to GPS it will figure out the length of the road, CH_ID which represent the cluster head id, CM_ID which represent the cluster member id, number of followers in the same lane, number of follower in a different lane, mobility information, FN_ID represents the FN which is connected with more than one CH and it represents the forwarding id. So all of this information will be hold OBU at each vehicle. When the vehicle state will change or it received the HELLO packet it modified the information table. Time state represents the effective time for route entry. If a vehicle does not receive the HELLOW Packet from a neighbor node at a specific time during the Time state the route entry will be deleted. Node range will represent the nodes in the same range of the specific CH.

3.5.3. Cluster State Change and Transfer Packet

In figure 9 we have shown the flow chart which shows the state that how it selects the state of nodes as CH, CM, and FN. From Selection of CH by finding out the priority, we select the highest priority node which becomes the CH, and the nodes which follow the CH become the CM. Cluster member (CM) that is related to numerous CH will set off the FN that will help to transfer the packet from source to destination. According to figure 6 at first, it will select the CH and then it will figure out the CM and from the CM it will select whether that cluster member (CM) is related with numerous cluster head (CH) or not. If it is connected with more than one CH it will become the FN. When it needs to transfer the packet from source to destination; at first it checks whether the destination and source are under the same CH or not. If it is not in the same CH range then the FN will help to transfer the packet from source to destination.

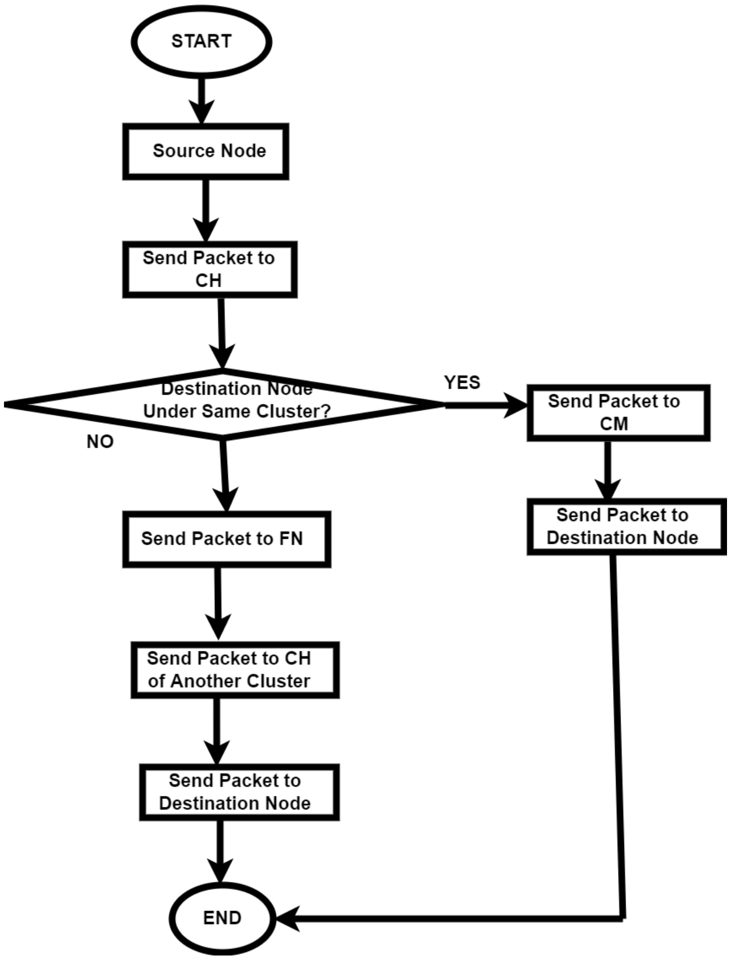

Figure 8: Proposed algorithm for transferring a packet from source to destination

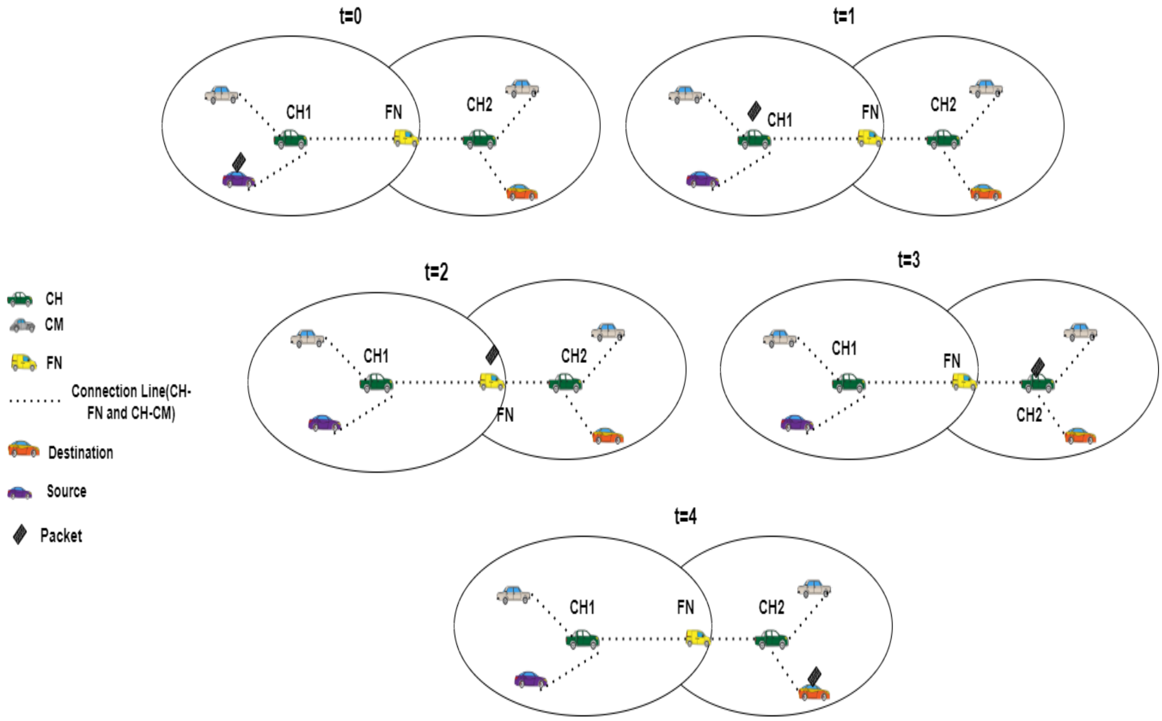

Figure 9: Transfering packet from source to destination

In this figure 10, the source node and destination node is under different cluster. Source us under CH1 and Destination is under CH2. When t=0 at that time packet was held by source. AT t=1 from a source the packet pass from source to CH1. AT t=2 when a packet passes through CH1 to FN. At t=3 from FN, the packet pass through FN to CH2. AT t=4 from CH2 to destination, the packet passes through.

3.5.4. Cluster Head, Cluster Member, and Forwarding Node Selection and the Whole Procedure for Transferring Packet

According to figure 11 and algorithm no 3.5.5, appearance it initial calculates the cluster head (CH) before calculation the precedence (mathematically named priority). Later acquiring cluster head (CH) at next step the node that is source shift the data or message to cluster head (CH) after that make the data board it will find out which vehicles are interior the alike scope of cluster head (CH). Accordingly cluster head (CH) just transfers data or messages to cluster member (CM). At the moment cluster member (CM) that is related with numerous CH will set off forwarding node (FN) after that FN send data packets to another cluster head (CH). Interior the hour boundary from the data set on condition that it breaks to send the data or mesages at that point of time it will do again the CH, FN, and CM formation. Also when it calculation the priority at that point of time because of calculating the mobility it will select the most stable node as CH and then it figures out the FN which is connected with more than one CH and this FN that assist to build the link more sustainable and within time state it can be transferred the HELLOW packet from source to destination.

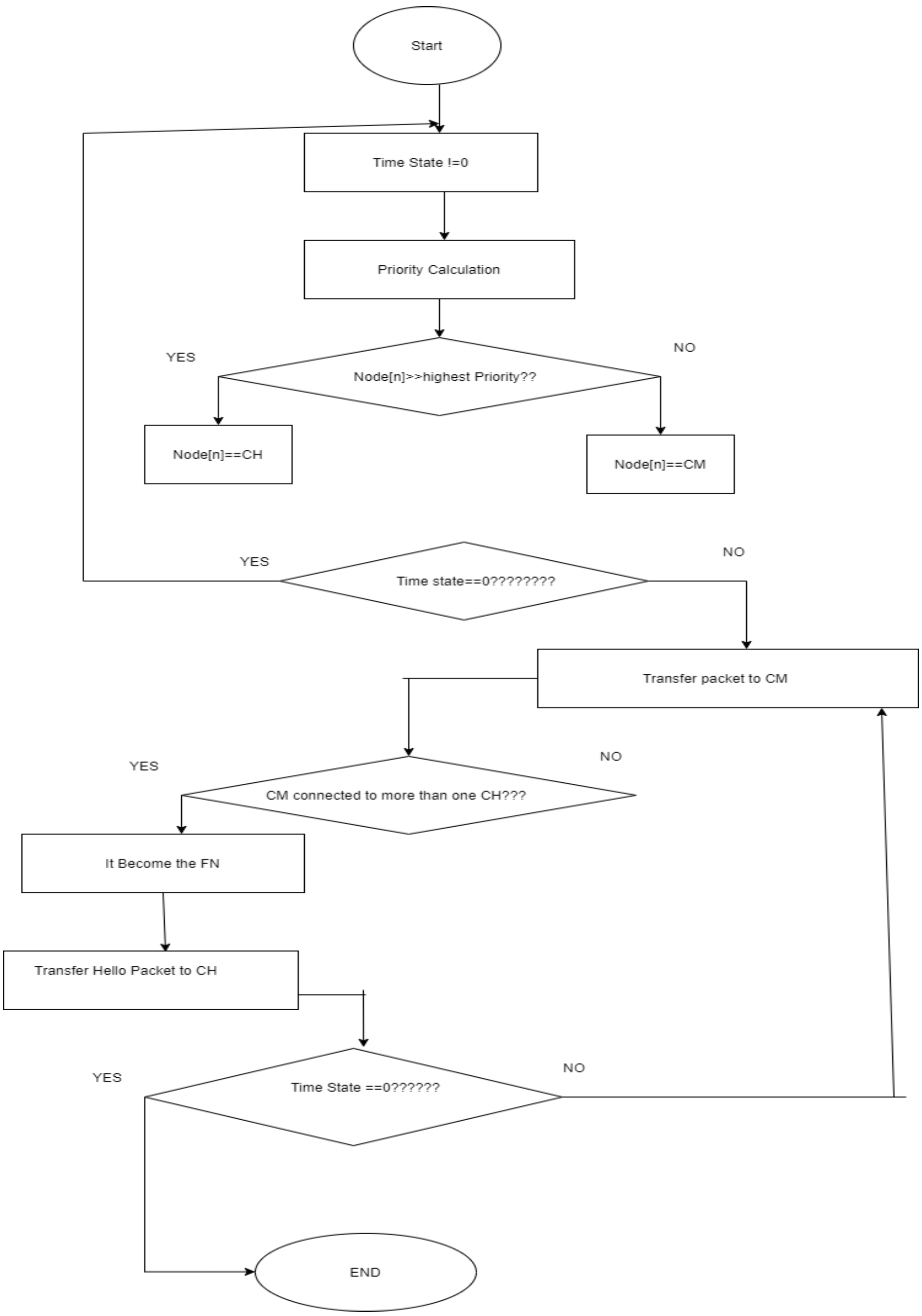

Figure 10: Flowchart for selecting CH, CM, FN and the whole transformation process

3.5.5. Algorithm for the Whole Process

1. $\boldsymbol{START}$
2. $Select\ CH$
3. $Select\ FN$
4. $Select\ CM$
5. $Send\ Hello\ Packet\ to\ CH$
6. $\boldsymbol{IF}\ Sender\ node\ and\ receiver\ node\ in\ the\ same\ cluster$
7. $\quad CH\ transfer\ Hello\ packet\ to\ CM$
8. $\quad CM\ transfer\ Hello\ packet\ to\ receiver\ node$
9. $\boldsymbol{END\ of\ IF}$
10. $\boldsymbol{ELSE\ IF}\ Sender\ node\ and\ receiver\ node\ in\ is\ not\ at\ the\ same\ cluster$
11. $\quad CH\ transfer\ Hello\ packet\ to\ FN$
12. $\quad FN\ transfer\ Hello\ packet\ to\ CH\ of\ another\ cluster$
13. $\boldsymbol{END\ of\ ELSE\ IF}$
14. $\boldsymbol{ELSE}$
15. $\quad Drop\ Packet$
16. $\boldsymbol{End\ of\ ELSE}$
17. $\boldsymbol{END}$

3.6 System Overview for Resource Allocation

In the architecture for a proposed system, we use 3 layers. Cloud layer, edge layer, and hop layer. In the hop layer, the vehicles will be the cluster members, forwarding nodes, and cluster hear.

Cloud Layer: In this layer contains the database of the vehicle information about the vehicle direction, road length, velocity, the value of computational resources. This will store the long-term data.

Edge-Layer: Network architecture can be found in this layer. Where there will be RSU/ Base Station/ Intelligent Traffic Light which will connect to the hop layer and cloud layer. Edge-layer gets the information from the cloud layer and transfers that information to the hop layer.

Hop-Layer: In this layer, there will be vehicles that will form multi-hop clustering. There will be CH, CM, and FN. This FN will help to connect from one cluster to another cluster.

Cluster Head (CH): CH directly connected with the edge layer. In the path layer, there is the roadside unit where the RSU will be directly connected to the CH and CH will get the information on which vehicle needs to offload resources and which vehicle have enough resource. This CH will format the clustering.

Cluster member: CM will directly connect to the CH. If the CM needs to offload the computational unit it will deliver the message to the CH and CH will check which CM can load the computational unit.

Forwarding Node: FN will help to connect from one cluster to another cluster in the hop layer. When a CM move on from that current cluster at that time if it needs to allocate resources so that information will be passed by FN to the CH of another cluster. So FN will help to transfer the information from one CH to another CH. The CM which is sharing both clusters will become the FN.

$|V(t)|$represents the set of vehicles within a specific time. In the sets of a vehicle, there is CH, CMs, and FN. Each CM wants to offer its available resource to its CH. A CM wants to offload its computational resource to the other CM if its local resource cannot satisfy the requirement [22]. CH finds out which CM needs the resource and which CM can offload the resource. CH decides which CM takes resources and which CM gives the resource. $V(t)$represents the vehicles that have available resources at that specific time of t. So $V(t) = \{v1, v2, v3, v4 \dots \dots \dots \dots \dots \dots \dots . vn\}$. $|V(t)|$ represents the total number of vehicles.$Vv(t)$represents a set of CMs in a cluster led by CH at a specific time t. So $Vv(t) \subseteq V(t)$ at the specific time of t. Computational resources are divided into blocks which represent by D. So $D = \{d1, d2, d3, \dots \dots \dots dn\}$. For establishing the cluster the

CH finds out the CMs and FN with the help of cluster formation formula [24]. So from the information table [24], the CH finds out which CM has available resources and which CM needs the resource. So All the vehicles under the CH are represented by $|V(t)|$. In figure 4 the CM2 needs the computational resource from CH. But at $t = 0$ the stability of CM2 is very less within the CH1. So at $t = 1$, CM2 becomes the member of CH2. So at $t = 0$, CM2 needs to allocate the resource from CH1 but as the time is so less so CM2 can't allocate the resource from CH1. When at $t = 1$, the CM2 becomes the member of CH2 it allocates the resource from CH2. But the information that how many resources CM2 needs, that information gets from CH1 to CH2 with the help of FN. If it works for single-hop at that point of time that CH2 needs to calculate and get that information from CM2 and it takes much time while with the help of FN CH2 does not need to calculate that information, CH2 directly gets that information from CH1 with the help of FN.

3.6.1 Communication Model

The computation tasks of the CHare given to the CMs by using V2V communications. We use the same transmission idea in the research paper [22]. The data transmission rate is represented by $\boldsymbol{d_{v,u}}$ where $CH\ v$to $CM\ u$.

$$\boldsymbol{d_{v,u}} = \boldsymbol{a\ log_2}\ (\boldsymbol{1} + (\boldsymbol{z_{v,u}} * \ \boldsymbol{x_{v,u}}/\boldsymbol{\sigma^2}_{\boldsymbol{v,u}})) \qquad [1]$$

Here $\boldsymbol{z_{v,}}$ represents the transmission power from $CH\ v$at $CM\ u$, and $\boldsymbol{x_{v,u}}$ is the channel gain. $\boldsymbol{a}$represents the bandwidth when transmitting computation tasks from CH v to CM u, and $\boldsymbol{\sigma^2}_{\boldsymbol{v,u}}$ represents the noise power.

The time for passing the computation tasks from the CH v to the CM u is represented as

$$\boldsymbol{Tram_u} = \boldsymbol{d_u}/\boldsymbol{d_{v,u}}\ , d_u \ \in D \qquad [2]$$

So the total transmission time for sending computational tasks from $CH\ v$ to $CM\ u$ is represented by

$$\boldsymbol{Tram_v} = \ \boldsymbol{\Sigma Tram_u} \qquad [3]$$

3.6.2. Computational Model

From the input data size, the output data size is very small, and returning time (tr_v) of the results can be ignored [22], that's why the returning results are zero in this paper. So the processing time of computation is represented as

$$\boldsymbol{tp = y * d_u / i_u * r_u, d_u \in D} \qquad [4]$$

Here y has represented the relationship between data size and the required CPU cycle count for the computation, $\boldsymbol{i_u}$ represents the ideal resource value in $CM\ u$, $\boldsymbol{r_u}$represents the computational resource (i.e. CPU clock frequency) of $CM\ u$.

3.6.3. Problem Formulation

Our object is to minimize the execution time of the computational tasks in the hop layer. In the hop layer, we are using the idea of multi-hop clustering with the idea of FN from our previous research paper [24]. The execution time is related to three parts: the transmission time $\boldsymbol{Tram}$, for sending blocks of computation tasks from the CH u to the CMs, the processing time for computation on the CMs $\boldsymbol{tp}$, and the time for returning the computation results from the CMs to the CH is tr_v. So our objective of this paper can be expressed by

$$\mathbf{min}(\mathbf{Tram_u} + \mathbf{tp} + \mathbf{tr_v})$$
$$\mathbf{where}\ \ (\mathbf{Tram_u} + \mathbf{tp} + \mathbf{tr_v}) \le \mathbf{tdur_v}$$
$$\mathbf{Vv}(\mathbf{t}) \subseteq \mathbf{V}(\mathbf{t})[5]$$

Here $\mathbf{tdur_v}$represents the duration of clustering with its CH, CMs, and FN.$Vv(t)$ represents the CMs under the same cluster with the help of CH v. equation 5 represents that the computational task must be completed before the CM leave from one cluster to another cluster.

For this reason, the CH needs to get the minimum number of time to calculate the computational tasks. So, this problem is considered as a Knapsack problem that proves to be NP-hard in [26]. To solve the problem, we propose a heuristic approach that jointly considers the duration of clustering and the computational capability of CH. The details of the scheme will be explained in 3.6.4.

3.6.4. Formulation of Multi-Hop Clustering

For predicting the time for clustering we use the timestamp, details description in our previous research paper [24]. First, the CH selects the candidates (which CM can allocate the resource) of CM, and then sends requests to the candidates. After receiving acknowledgments (ACKs) from the candidates (CM), the CH confirms the CM. Then, the computation tasks can be offloaded from the CH to the CM.

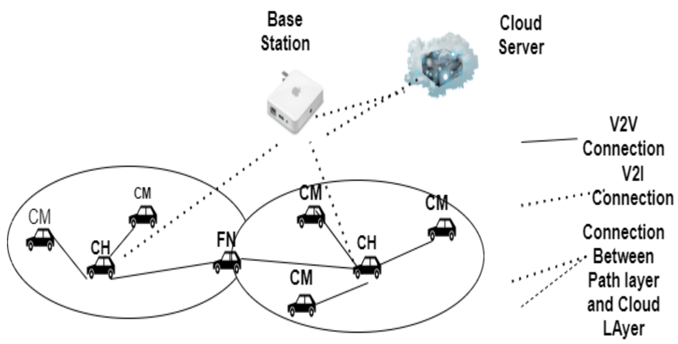

Figure 11: Clustering formulation with edge-layer and cloud Layer.

According to this figure, 12 Cloud servers will have a long-term information table. It will collect vehicle velocity, vehicle mobility, computational unit information, and whether that specific vehicle has enough resources or not. CH will directly connect with the path layer (Base station) and the CM and FN. Where CH will calculate the computational unit and CH will get the information from CM that which CM needs resources and which CM has enough resources.

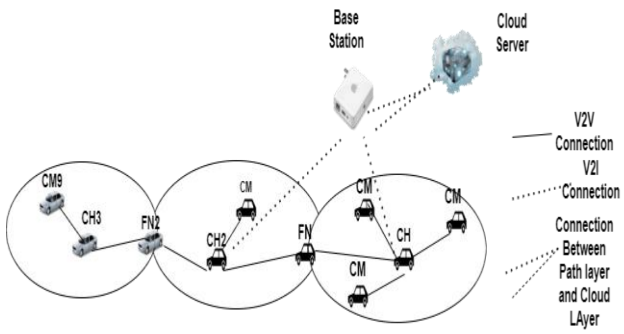

Figure 12:Outside the coverage of edge-layer

In figure 13 the CH 3 is the outside the range of edge-layer so in that time through the FN2 which makes a connection between CH3 and CH2. So the information will pass through the FN2.

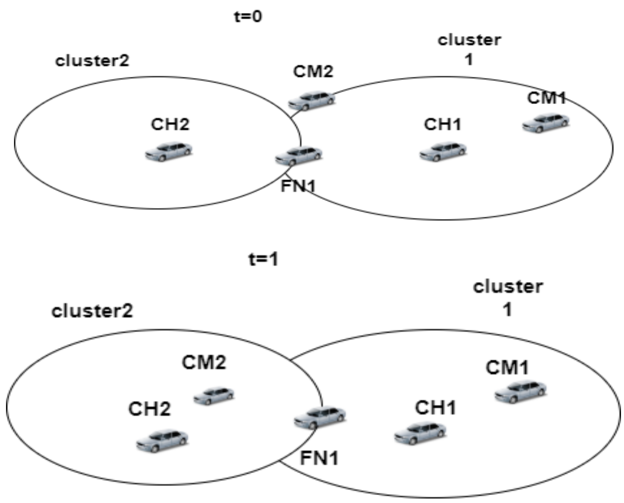

Figure 13: An example of collaboration of multi-hop clustering for resource allocation

According to figure 14 when$t = 0$ the CM was in cluster 1 and it need resource allocation. So CH allocates the resource. At time $t = 1$ the CM2 become the under of cluster 2 but it needs resource to allocate what it can't completely allocate from Cluster 1 so this allocation message that the left-over resource that CM2 can't collect that message will pass through FN1 to CH2. So by this way, the FN will work to transfer the message from one CH to another cluster head.

So for resource allocation, the CH will calculate which CM will offload the computational unit and which CM will be available to hold the computational unit. CH will distribute the computational unit to the CM. Now according to figure 5, the CM2 needs the resource from CH1 but the CH1 can't pass the resource because of time-consuming. At $t = 1$ the CM2 become the member of CH2. SO at that time, the CH2 does not need to calculate which CM needs the computational unit as CH1 and CH2 both are connected with FN1 so FN1 will transfer this message to the CH2. So then CH2 will give computational resources to CM2.

3.6.5. Architecture for Resource Offloading

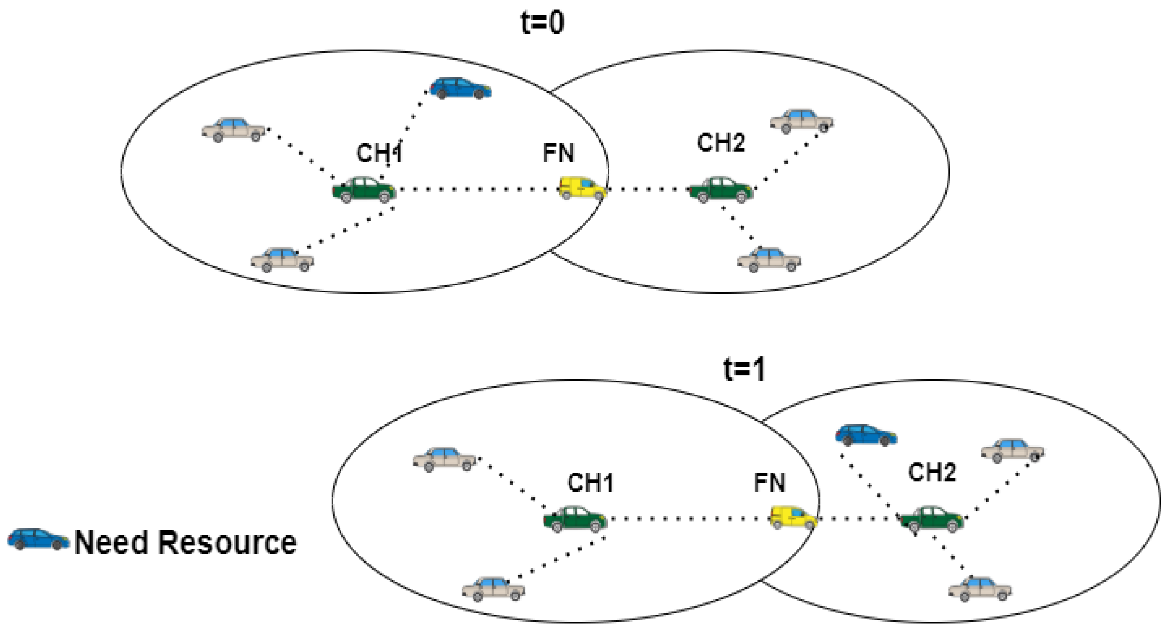

Figure 14: Architecture for resource offloading

According to figure 15, represents offloading resources from one CM to another CM. At $t = 0$ the blue car needs resources but at $t = 1$ that blue car becomes the CM of CH2. SO at that time $t = 0$, CH1 can't offload resources to that car. SO when at $t = 1$ that CM go to CH2 at that point of time through the help of FN the CH2 get the message that CM needs a resource, and CH2 offload the resource to CM. With the help of FN CH2 does not need to calculate how many resources CM needs, by FN it get that message and offload the resource to CM.

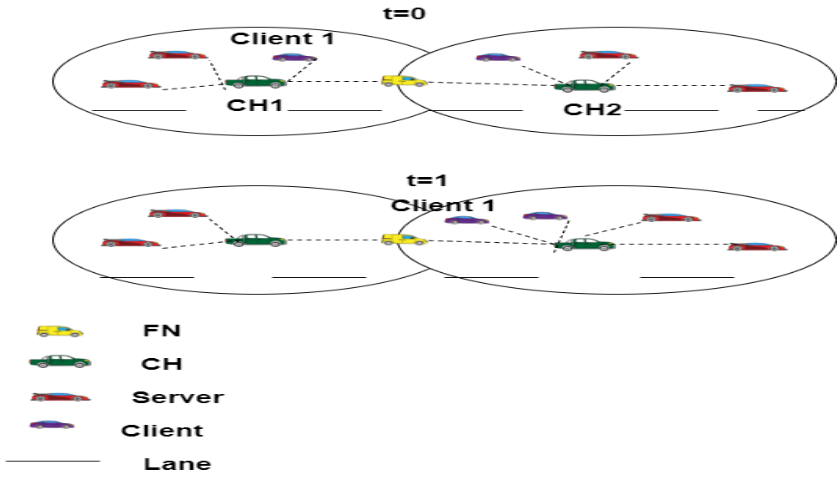

Figure 15: Architecture while client move from one cluster to another cluster

According to figure 16, when $t = 0$client 1 which need resource is under CH1. CH1 has 2 server nodes that can offload the resource to client 1. But at $t = 1$, client 1 becomes the member of CH2. So now CH2 does not need to calculate how many resources client 1 need. With the help of FN, the information about client 1 that needs resources this information will pass through the FN from CH1 to CH2. SO CH2 does not need to calculate how much resource client 1 needs.

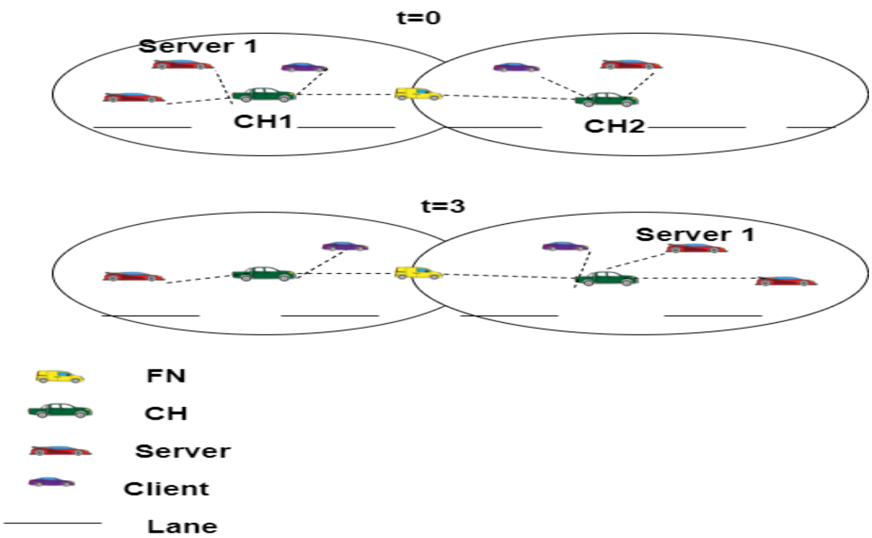

Figure 16: Architecture while server move from one cluster to another cluster

According to figure 17, at $t = 0$ server 1 is under CH1. So CH1 has the information about the server which can offload the resource. At $t = 3$ the server 1 go under CH2 and with the help of FN CH2 get the information about server 1

The server will offload the resources and the client will take the available resource.

3.6.6. Processes for Clustering Establishment and Computation Offloading

1. ***START***
2. *Select the CH*
3. *Select CM*
4. *Select FN*
5. *From the Information table CH will get all information about the vehicles inside the same clu*
6. ***If*** $(CM\ duration > computation\ unit\ calculation\ time)$
7. *Offload computational unit to CM*
8. ***END of IF***
9. ***Else***
10. *FN transfer the BSM to the another CH to another cluster(From BSM information table already the direction of each vehicle is given so FN will get the message from CH in the next direction)The new CH will offload the resource to CM*
11. ***END of ELSE***
12. ***END***

Chapter 4

Results for Link Stability and Resource Allocation

4.1Results for Link Stability

We have imitated the submitted clustering construction applying an investigational frame operating SUMO ; NS-3. We applied Simulator of Network (NS-3) deploy results by imitating the vehicular ad-hop network [21]. At first, we applied SUMO (Simulation of Dhaka Velocity) afore imitate vehicular ad hoc network as velocity diagram applied. At second, the track down folder upgraded before SUMO is applied by NS-3 to pass that result and create proof.

For variant investigations, we possess many amount nodes beginning at 10 afore 1000. Every nodes applies on the path with a various mobility from the variant of 5 to 45 km/h. The transference scope of the Road Side Unit and On Board Unit are applied afore 350 together with 150 m. Every imitated applies continue for 350 s together with the answers among 60 results applies are mean behalf of every result point of the charts. The imitated variables are record in Table I. Thought balancing, treble more breakthrough are applied: PMC, VMaSC, DMCNF.

Table 2. Simulation Variables

Variables	**Values**
Result (Simulation) hour (in seconds)	350
Maximum Velocity (m/s)	5 - 45
Vehicles Number	10 - 500
Range of Transmission (m)	150 - 350
The protocol that is applied for MAC	802.11
Beacon packets for interval (s)	350
The size of Beacon Packets (bytes)	64
Trails Number	60

Those variables applied afore quantify presentation of the proposed clustering algorithm are come after:

4.1.1 Duration for Average Cluster Head(CH)

CH is the major node for our proposed architecture. We need to make the CH stable. From our proposed algorithm we find out the most stable CH that will stay maximum number of time.

4.1.2 Average Cluster Member duration

CM is another secondary node for our proposed architecture. CM geed the data from CH. If the CM moved from one CH to another CH so the data pass from that specific CM with the help of FN

4.1.3 Changes of Cluster Head (CH)

Amount of cluster head (CH) convert turn on density and the mobility of the vehicle. So for our proposed architecture CH is the major node and CH changes need to be minimized. When the CH changed less time at that time link will be more stable. So CH changed must be less.

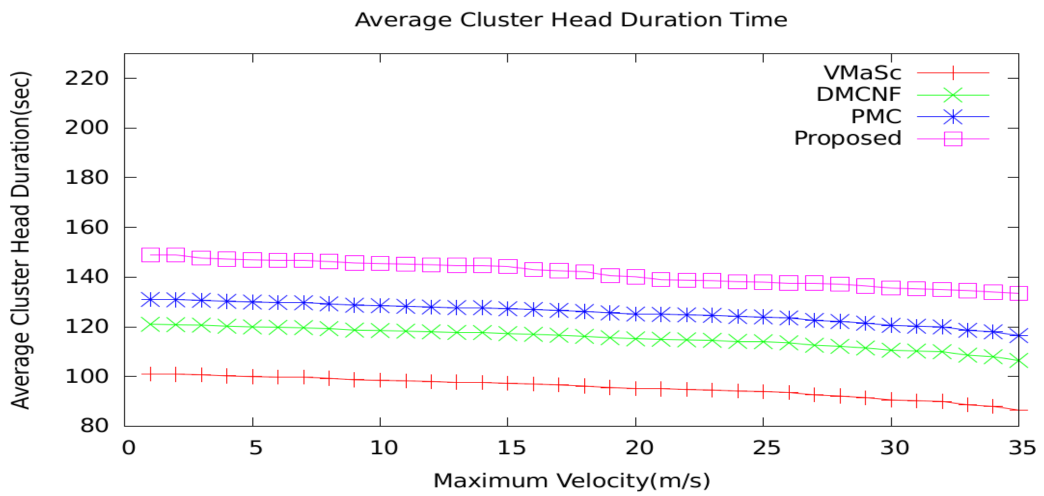

Figure 17.Average Duration time for cluster head (CH)

Given in Figure. 17, the average duration time for the cluster head is best for the proposed algorithm that selects the best sustainable CH. Through our proposed algorithm we get the best sustainable vehicle that will become cluster head (CH). As from the figure 17 we can see our proposed algorithm provides the most stable CH than the other algorithms. So figure 17 proved our proposed algorithm is better than other 3 multi-hop clustering algorithms.

Fig. 18 appear the average changes of CH for the proposed algorithm as we know according our research the CH is the major node among other nodes. So for that purpose if the CH changes a lot of time it will create problem and link can't be stable at all. Our proposed algorithm find out the most stable CH and that's why the change of CH is very less than other multi-hop clustering algorithms. So from figure 18 it proved that our proposed algorithm provides the better result than other algorithms.

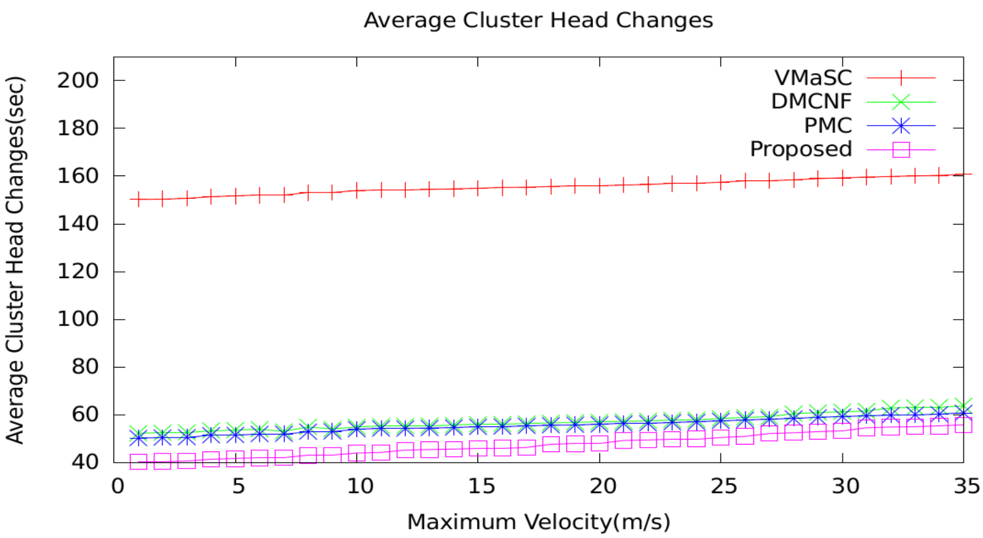

Figure 18:Average cluster head changes

Figure 19 shows the average cluster member duration time . In our research CM is the secondary node that is also very important to make link stable. From figure 19 it proved that our proposed algorithm provides better result than other multi-hop clustering algorithms when it comes about CM change timing. CM duration also very high so the changes of CM is very low that provides the better result than other algorithms.

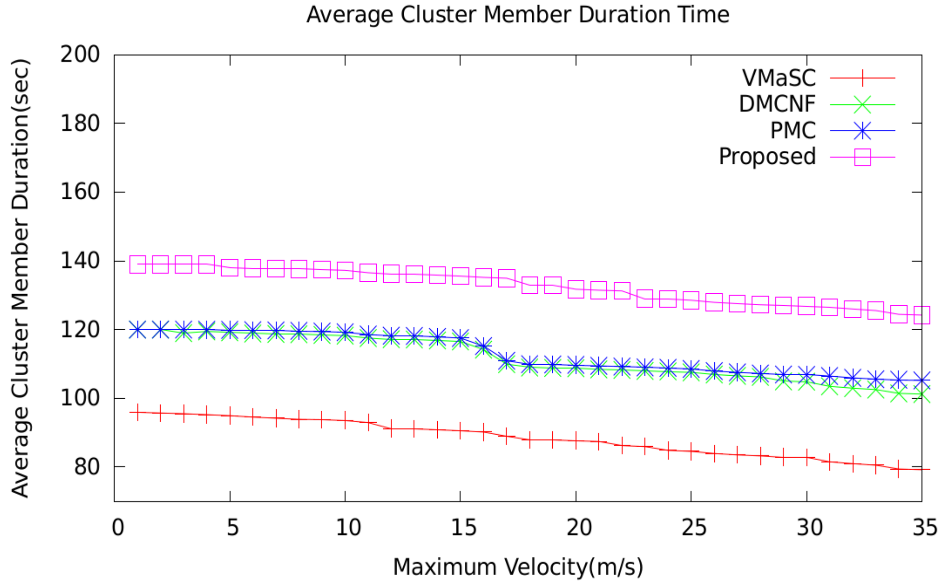

Figure 19: Average cluster member changes

4.2 Results for Computation Offloading

We have imitate the proposed algorithm for resource allocation and architecture with help of SUMO and NS3. We used network simulator 3(NS-3) to find out the simulation for the VANET [21].In the first step, we use SUMO (Simulation of Urban Mobility) afore calculate vehicular ad-hoc networks like velocity, mobility model generate. At 2nd step we use NS3 to pass a mathematical result along with create the proof.

Table 3. Simulation Parameters for Resource Allocation

Parameters	**Values**
Simulation time (in seconds)	300
Reference speed of a vehicle	50 km/h
The number of vehicles	150
The bandwidth of V2V communications	10 MHz
Interval of sending BSM	1 second
MAC protocol use	802.11

For the different experiments, we used various numbers of vehicles 150. It selects randomly the CM. To find out the simulation result the parameters we were using

- Proposed Diagram (Proposed)=considers the link duration between CH and CM and the total available computational resources among the CM of that under particular CH

Algorithm for Calculation Prop

1.$\boldsymbol{Start}$

2. From information table CH find out the BSM message(velocity of CM, road length, resource unit)

3. Find out link duration(distance between CH and CM using array)

4. Calculate total resource(using array and adding all the available resources from CM)

5.$\boldsymbol{Prop = total_{resource} + link_{duration}}$

6. END

- Rand: randomly select CM among the hops. For example, if there are 10 hops select 3-5 CM from each hop
- Minimum distance first (Distance_based) selects CM with
- comparatively shorter distance to the CH (for coding using array and from BSM it finds out the distance and velocity)

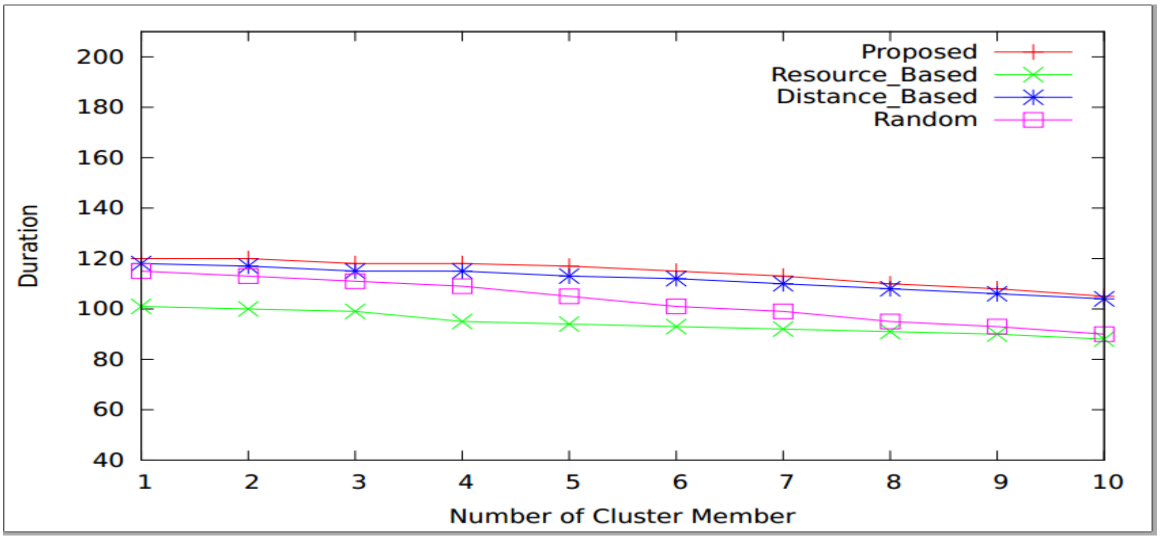

Figure 20: Duration time for multi-hop clustering for CM (without clustering maintained)

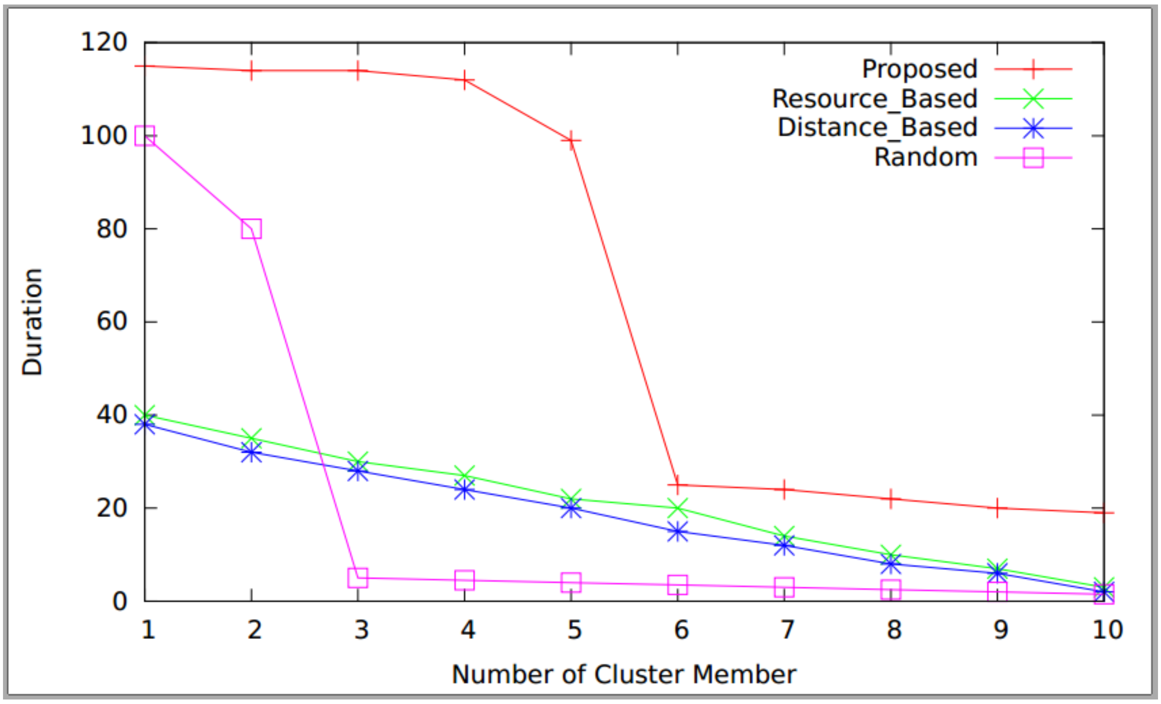

Figure 21: Duration time for multi-hop clustering for CM (with clustering maintained)

According to Figures 21 and 22, we can see the prop value was stable up to cluster member number 4 but according to time and it increase the CM number it falls. But when we use and maintain the cluster we can see there is a balance in the proposed value. That is depending on link duration and total available resources. When it does not maintain a cluster it is easy for 2-4 nodes for balancing within time but with time when the CM also increases the prop vale fall. But if we maintain cluster so it easily finds out the path duration, link duration and also get the vehicles (nodes) are under the scale of that hop, which CM is under that CH and that's why there is a balance in a proposed graph.

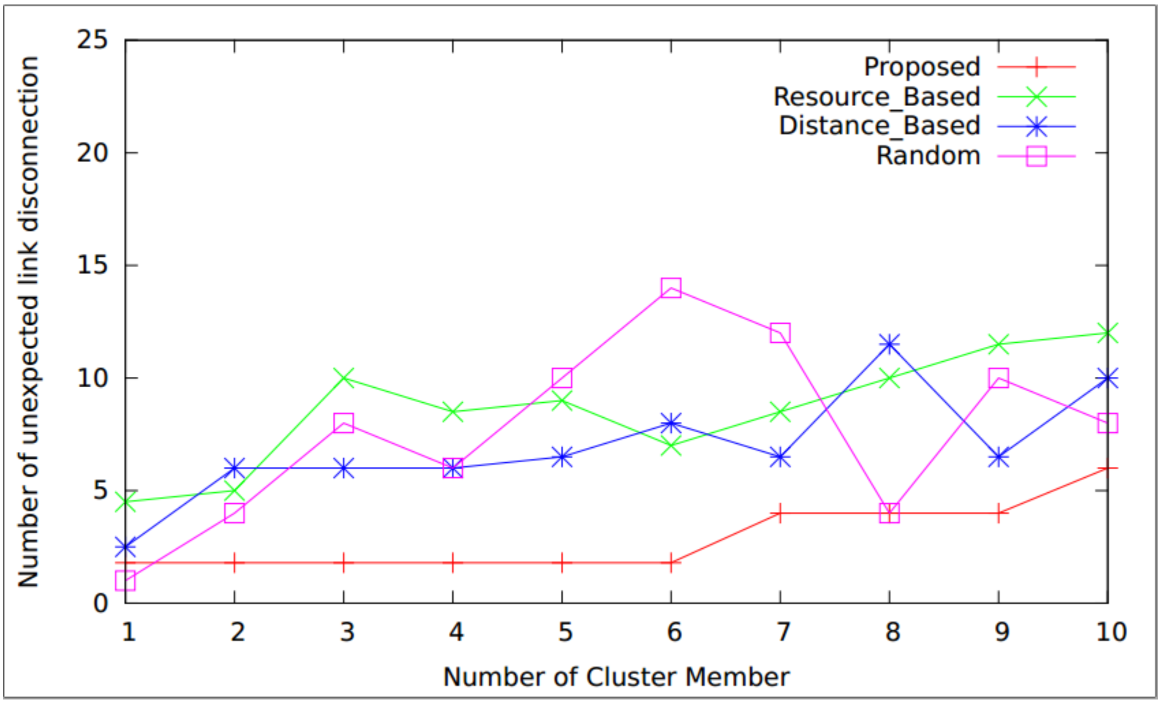

Figure 22: The number of unexpected link disconnections for different numbers of vehicles while there is no clustering.

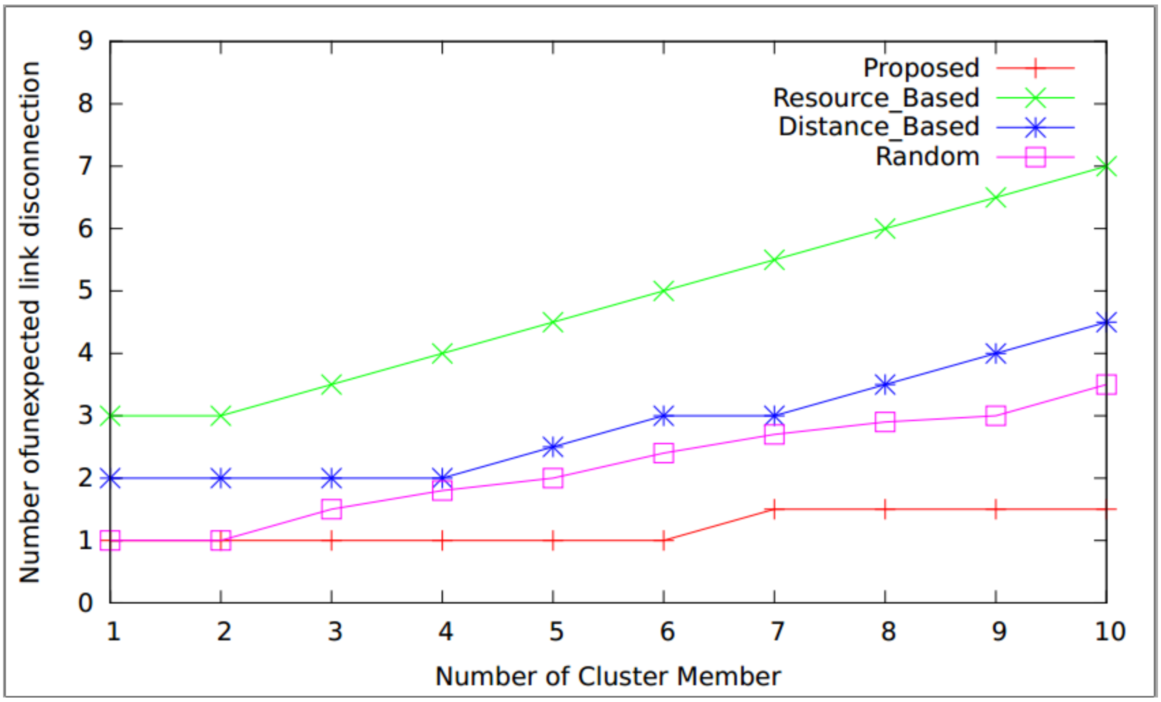

Figure 23: The number of unexpected link disconnections for different numbers of CM while there is clustering.

So between figure 23 and figure 24, we can see while there is no clustering the unexpected disconnection for finding out the resource allocation and calculating the computational unit is just up and down as randomly it select vehicles for calculating computational resource and it can find out that sometimes it can happen that vehicle which has the computational unit it needs to offload but the car it offloads it become outside of the range. But while we using clustering at that point of time we can see there is a minimum increasing range even it provides a better result than there is no clustering formation. As there is clustering formation at that time CH has the idea of which CM is under its range, how much time the CM will under this range and even if any cluster member will move to another cluster at that point of FN will deliver the message about that new CH about that CM. So that's why our idea provides a better graph than figure 23.

Chapter 5

Conclusion and Future Works

5.1 Summary

There are lots of research options in VANET. But the most challenging is to make the link stable. As vehicles are moving continuously and direction also changes which make a big challenge to make link stable. As vehicles are moving so topology also changes. So it's very critical to make a link table. As the link is not stable CH and CM also change a lot of time. As the nodes are changing their position continuously so it's really very challenging. Also, the nodes are changing their position continuously so problems also occur in resource allocation too. It provides major performance in systematic routing in vehicular ad hoc networks. Many parameters connected with the systematic of link sustainability on network production. At our thesis, we suggested a well contracture clustering scenario which appraises link sustainability along with velocity at VANET for turn down aloft for hop organization along with conservation. The proposed scenario results in sending the data or message flexibility near applying the less hops or clusters number from the node which is source vehicle to the vehicle which is destination. Resource allocation is another important topic in VANETs. We studied some good papers about resource allocation. But in that part, it works for a single hop. So we apply our multi-hop clustering idea for resource allocation. We provide the idea as instead of multi-hop if we use single-hop it will take more time but when we use multi-hop it is faster. There are a lot of challenges and problems in VANET [10]. Some problems are[24]:

- Stoppage (If the source node and destination node is very far away not possible to transfer data packet.)
- Awful achievement because of continuous break up.
- Demolition of bandwidth because of accident of packets
- Caching issue because of less of intermediate storage
- Unstable or unpredictable links .

From our research study we figure out there are a lot of challenges related with VANET. Among of the challenges we work on 2 challenge. One is link stability and second one is the resource allocation timing. In our research our focus to apply link stability with the idea of link stability we think how can we make minimize the timing for resource allocation. Our major focus is to get the best sustainable vehicle (node) as cluster head (CH) that will change it's state minimum time and that will stay in the cluster for the maximum time. Our second focus is that for resource allocation to minimize the timing as quickly as possible it will offload the resource and every time CH does not need to count the statement of the node whether it is a client or server. For that purpose we apply to minimize the time for resource allocation

We imitate the proposed clustering algorithm along with collate it in the company of few another clustering algorithms through the existence conference and journals papers and answers exhibit the flexibility of our proposed scenario and algorithm.

5.2 Possible Extensions and Future Works

In the time ahead, we require to enlarge the prefer scenario for additional multiplex along with actual scenarios along with absorb few assistance girding possibility afore inspect it advantage in dissimilar applications. Some of the possible directions to extend our work are discussed as follows:

5.2.1 Applying Machine Learning Techniques

With the exponential growth of number of vehicles in the road and diversified requirements of heterogeneous resource-hungry services and applications, it becomes increasingly difficult to optimally solve the problem of cluster formation and maintenance and dynamic resource allocation among the vehicles. Applying machine learning techniques can be a promising solution in this direction.

5.2.2 Adding more VANET-Specific parameters in CH Election Process

Newer strategies and metrics, which fully exploit more VANET-Specific features or characteristics can be added to get more realistic output, such as predicting future mobility patterns and channel behavior from historical data.

5.2.3 Backup CH Selection

Some measurement of intention of the drivers like using indicator signals to predict lane change or future exit will help to utilize wider range of metrics that will assist in routing and resource allocation decisions, such as deciding that a vehicle is no more suitable for CH because it is about to leave the highway, so a new backup CH should be selected to take over. This will improve the efficiency of routing and resource allocation.

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