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Safety Message Dissemination Scheme Using Bloom Filter based Clustering in VANETs

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Dedicated to:

My Family.

Declaration

I understand, declare that this thesis entitled as "**Safety Message Dissemination Scheme Using Bloom Filter based Clustering in VANETs**" is my original work and this thesis is not been presented for degree in Jimma University or other universities and all sources of reference used for this thesis have been properly acknowledged.

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Approved by a board of Examiners

This independent research entitled as "**Safety Message Dissemination Scheme Using Bloom Filter based Clustering in VANETs**" is been read and approved as meeting the preliminary research requirements of the School of Computing in partial fulfillment for the award of the degree of Masters in Computer Networking.

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Abstract

A Vehicular Ad-Hoc Network or VANET is a type of Mobile Ad-Hoc Network (MANET) that provides communication between vehicles and between vehicles and road-side unit (RSU) or road-side base stations. It also introduced challenges that comes with unique characteristics of VANETs like frequent node disconnection, high mobility of nodes, fast topology changes, and limited bandwidth as compared to MANET. The characteristics of VANETs is difficult to handle different problems of this network specifically when emergency events need solution, it is more challenging when compared with other general ad-hoc network scenario. With this unique characteristics a number of problems is introduced in VANETs message disseminations like channel overhead, message redundancy, and packet delay is the major one. So, to address this issues in case of safety message dissemination, probabilistic data structure called bloom filter used to manage the neighbor nodes for better message dissemination. Depending on the collected information about the neighbor nodes we designed the algorithm which integrates this bloom filter data structure and clustering for the purpose of safety message dissemination in VANETs. The methodology used for the study is problem identification using review of literature and related works and then modeling the conceptual model for message dissemination. And then existing dissemination scheme is identified. The new scheme is investigated based on the constraints identified over the highway scenarios. Different tools are used for this purpose are of network simulators and mobility generators such as NS2, OMNET++, SUMO and Veins. After implementing the designed algorithm we performed the simulation using the above listed tools and finally performance evaluation with related scheme is analyzed. From the comparison we identified the new scheme improved the number of informed nodes with the average of 7% of the performance of the number of informed nodes of VANETs comparatively with related schemes.

Keywords: VANET, Bloom Filter, Clustering, message dissemination

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Acronyms, Abbreviation and Terminology

BFBC:	Bloom filter based clustering
CBEMD:	Cluster Based Emergency Message Dissemination
DSRC:	Dedicated Short Range Communication
GPS:	Global Positioning System
ITS:	Intelligent Transport System
MAC:	Medium access control
MANET:	Mobile Ad-hoc Network
MOVE:	Mobility Model Generator for Vehicular Networks
OBU:	On board unit
RSU:	roadside unit
VANETs:	vehicular Ad-hoc Networks
SUMO:	simulation in urban mobility
VEINS:	Vehicles in Network Simulation
V2I:	vehicle to infrastructure
V2V:	vehicle to vehicle
WAVE:	wireless access in Vehicular environment
WSMP:	WAVE short message protocol
ITS	Intelligent Transport System

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CHAPTER ONE

1.1. Introduction/Background

A Vehicular Ad-Hoc Network or VANET is a sub form of Mobile Ad-Hoc Network (MANET) that provides communication between vehicles and between vehicles and road-side unit (RSU) or road-side base stations. The aim of this communication is providing efficient and safe transportation. A vehicle in VANET is considered to be an intelligent mobile node capable of communicating with its neighbors and other vehicles in the network. VANET introduced more challenge like frequent disconnection of nodes, high mobility of nodes, fast topology changes, and limited bandwidth as compared to MANET. Safety and traffic management entails real time information and directly affect lives of people travelling on the transportation area or roads [1] [2]. A vehicular Ad-Hoc Network is also used to provide communications among nearby vehicles to allow flexibility and mobility to the wireless network topology. The main aim of VANETs is providing safety and comfort for passengers. Each vehicle equipped with VANETs device will be a node in Ad-Hoc network and can receive and relay others messages through the wireless network. Collision warning, road sign alarms and in-place traffic view will give the driver essential tools to decide the best path along their way [3].

VANET is one of the fastest emerging technologies for research as there are many issues and challenges to be addressed by the researchers before the technology becomes commercialized. Vehicular communication systems developed largely by the growing interest in ITS. Cooperative driving can improve safety and efficiency by enabling vehicles to exchange emergency messages to each other with their neighborhood. This is used to assist driver in making proper decision to reduce the probability of vehicle collisions and congestion [2] [4]. Information exchange in VANET can achieve effective communication between moving node by using different ad-hoc networking tools such as WAVE, and DSRC [5].

Regarding safety, efficient message dissemination schemes are required, since the main target is to decrease the latency of such critical data while ensuring the correct reception of event information by neighbors [6]. When a vehicle detects an abnormal circumstance (e.g., road works, accidents, and bad weather), it immediately broadcasts the incident to neighboring vehicles. And then rapidly spreading the information to aware the nearby vehicles allow the nodes to take a good decision of their way which have good advantage for ITS. Broadcast transmission is usually used for disseminating safety related information among vehicles. Broadcast over wireless networks poses many challenges due to link unreliability, message redundancy, and broadcast storm, which greatly degrade the network performance. In all this process, the selected dissemination scheme have a great importance [2], [3].

A Bloom filter is a space-efficient probabilistic data structure which is used to (probabilistically) test whether an element is member of a set. The information of the neighbor node is collected by bloom filter by creating the neighbor table for information management. Bloom proposed the technique for applications where the amount of source data would require an impractically large amount of memory if "conventional" error-free hashing techniques were applied. An empty Bloom filter is a bit array of m bits, all set to 0. There must also be k different hash functions defined, each of which maps or hashes some set element to one of the m array positions, generating a uniform random distribution. Typically, k is a constant, much smaller than m, which is proportional to the number of elements to be added; the precise choice of k and the constant of proportionality of m are determined by the intended false positive rate of the filter. The other technique that we used in this study is clustering, which is more advantageous and suitable for highly dynamic networks like VANETs. Clustering is mostly used to eliminate broadcast storms as compared to using simple flooding or flat topology for a message disseminations in such highly dynamic networks. With the cluster-based scheme, nodes are supposed to be divided into a set of clusters. A cluster is a subset of vehicles forming a convex network [8]. Clusters are supposed to be disjoint, i.e., a node can belong to only one cluster. These clusters are used for different purposes: implement efficient broadcasts or create a hierarchy in the network allowing network protocol (particularly the routing protocols) to scale to any network size. A lot of clustering protocols like affinity propagation algorithm, hybrid backbone, and priority based data handling have been proposed for ad hoc networks and VANETs. Generally, a node in a cluster is classified as head, gateway, or member. The head, also called cluster head, is a particular node used to build the cluster. There is only one head for each cluster and it is often at the core of its cluster. Gateways are the nodes sharing a link with another cluster. Members are the nodes which are neither heads nor gateways [3], [9].

The proposed study will investigate the efficient way of message dissemination in vehicular ad-hoc networks by employing integrated Bloom Filter based Clustering scheme. The vehicles which acts as the node in VANETs is just first collects their neighbor information by using Bloom Filter. The information about the neighbor node is stored on the neighbor table management. Up on the information collected the cluster formation is done depending on the algorithm created to form cluster in this study. When the node identifies there is a situation which is not normal in the VANETs network that node is elected as cluster head and initiates the dissemination of the message to their neighbor member nodes. This way of dissemination is provided by using the algorithm that is investigated for coupling Bloom Filter with clustering technique.

1.2. Statement of Problem

Vehicular Ad-hoc Networks is facing many issues such as high mobility, high latency, irregular network, and signal fading currently. Among these challenges, message dissemination is the very popular one in our today's world according to different researchers of VANETs recently in the couple of decades. This is because of the technology is emerging smartly to use the future technology including VANETs which is dependent on the active communication of the nodes. The importance of investigation of efficient message dissemination has long been recognized by many researchers. However many of message dissemination schemes provided still have drawbacks like channel overheads while dissemination. This is the cause for frequent loss of data to be sent and ineffective message dissemination among nodes of VANETs. The primary issues of VANETs is merely come through the cause of unique characteristics of vehicular networks. High mobility, frequent topology change, unbounded network size, time critical and variable network density are some of VANETs characteristics. The characteristics listed above is the major cause for the inefficiency of message dissemination in VANETs. This study starts with the idea of neighbor node management proposed in [10]. According to the study, they used bloom filter on flat topology to improve collisions and to reduce the channel overheads to some optimum performance when compared with schemes which do not considered this bloom filter. This study used Bloom Filter to manage the neighbor management schemes which is then used to broadcast message. Despite the fact that the contribution of the study to the issue we are interested in (i.e. message dissemination), the study still have problems which can frequently be the fundamental limit for efficiency of message dissemination. First, the flat network topology they used is the cause for scalability and reliability issues especially under dense networks. And also overhead on wireless channels which is the cause for inefficiency of message dissemination. Second, the data transmission is done by selection of 1-hop forwarder nodes and there is no selection of desired direction of message propagation instead they simply identifies next hop for forwarding. This way of forwarding strategies is the cause for the load on the wireless channel due to large number of nodes used to forward messages. The node which is selected as 1-hop for transmission may not globally best for message forwarding to the next node which is the cause for channel overhead.

In this paper, we are going to investigate the scheme which integrates Bloom Filter with clustering techniques together to address the gap identified. In summary, there is a need for a better way of message dissemination and structured scheme in vehicular ad-hoc networks to which improves wireless channel overhead. More specifically, the following research question needs to be addressed:

- What effect do integration of clustering with bloom filter have on safety message dissemination of VANETs?

1.3. Objective

1.3.1. General Objective

The general objective of the study is to investigate integration of the Bloom Filter with clustering techniques to improve safety message dissemination in vehicular Ad-hoc Networks (VANETs).

1.3.2. Specific Objectives

Particularly, the proposed study has the following specific objectives to achieve the overall goal of this study:

- To provide a comprehensive review of sources and characteristics of message dissemination typically found in VANETs.
- To create a neighbor node management using Bloom Filter properties.
- To design an algorithm which is used for the integration of bloom filter with clustering.
- Creating cluster depending on the designed algorithm.
- Providing the suitable message forwarding strategies for clustered nodes.
- Evaluating the results by using simulation tools over simulation environments.
- Performance evaluation of the scheme

1.4. Methods

The primary method for this study is literature review and conceptual modeling of message dissemination in VANETs. Problem identification through the review is the very first step towards achieving the final goal of the study.

This study will first review various characteristics of message dissemination in VANETs. Based on the understanding, the efficient constraints will be provided to address the issues identified for the purpose of efficient message dissemination in vehicular ad hoc networks.

In the second stage of this study, the existing dissemination scheme will be identified based on the comprehensive review of current studies and academic researchers.

And then the new scheme will be developed based on the constraints identified over the highway scenarios. The scheme developed will be implemented. Simulating using necessary simulation tools over simulation environments by coupling SUMO road traffic mobility generator with the network simulator OMNET++ using Veins on NS2.

Finally evaluating performance of the study results using different metrics and analyzing results of the investigated scheme in the proposed work.

1.5. Scope (Limitation and Delimitation)

The overall scope of this study is more specifically aiming at the improvement of message dissemination in Vehicular Ad-hoc Networks (VANETs) over the highway scenario. The proposed study will design the algorithm for integration of bloom filter with clustering techniques to improve the data dissemination in VANETs. The proposed study is limited to improvement of message dissemination scheme. This thesis do not consider the security issue while message forwarding among neighbor nodes, and not cover the best route selection while data dissemination because of vastness of the paper and time limitation.

1.6. Application of Results

As the application of vehicular ad-hoc networks is applied over the transportation, the primary user is passengers and intelligent transport system. The thesis proposed is going to provide the best scheme for message dissemination among the neighbor vehicles. Message dissemination helps the driver for taking a good decision of their way of VANETs over highway scenario. This scheme provide the best way of road and node managements for ITS.

1.7. Thesis Organization

The organization of this thesis is as follows. Chapter 2 introduces about different literature reviews of Vehicular ad-hoc networks and the overviews of VANET technologies and message dissemination techniques are discussed. Chapter 3 provides a brief description about related works on safety message dissemination of VANETs which is with or without bloom filter. In Chapter 4, we extend the proposed models and algorithms focusing on the bloom filter data structure. Chapter 5 discusses highlights of the simulations and evaluation of the proposed model. In Chapter 6, we extend our study by concluding, recommending the future work and the contribution of the study is discussed.

CHAPTER TWO

2. Literature Review

2.1. VANET (Vehicular Ad-hoc Network)

Vehicular Ad-Hoc Network or VANET is a technology that has moving vehicles as nodes in a network for creating a mobile network. VANET is a type of MANET which is a next generation networking technology that provides communication between vehicles or between vehicles and RSU using wireless communication [11]. The ITS, through its derivative system named VANET allows vehicles to exchange information relating to safety and comfort of drivers and passengers. We can say that VANET turns each and every vehicle into a wireless node, allowing cars to connect to each other which are 100-300 meters apart and, in turn, create a wide range of network. As the cars fall out due to signal range and drop out of the present network, other cars can join in to connect vehicles to one another so a mobile Internet can be created. It is assumed that the first systems in which it is integrated are police and fire vehicles to communicate with the other vehicles to provide safety. VANET uses the DSRC in order to provide wireless communication between vehicles and providing safety messages in order to warn drivers [3], [11], [12]. Vehicular network is a term which is used to describe the spontaneous ad hoc network that is formed over vehicles moving on the roads. Vehicular networks are very fast emerging for deploying and developing new and traditional applications. It is characterized by rapidly changing topology, high mobility, and ephemeral, one-time interactions. Both MANETs and VANETs are characterized from the movement and self-organization of the nodes (i.e., vehicles in the case of VANETs). Communication equipment fixed in the vehicles makes it possible to send and receive messages. Two categories of VANET communication used: V2V and vehicle to infrastructure named V2R. In the V2V communication, vehicles act as relay nodes to ensure the exchange of messages between them. In V2R communication, RSU act as relay nodes to transmit information to nearby vehicles and RSUs. The communication is needed generally to provide non-safety and safety services including emergency information as well as anti-collision messages and alerts [11], [13]**.** The general overview of ad hoc network have many entities involved in a VANET settlement and deployment. Although the vast majority of VANET nodes are vehicles, there are other entities that perform basic operations in these networks. Ad-hoc networks have the following entities in perspective of vehicular networks: They are equipped with three different devices. Firstly, they are equipped with a communication unit (OBU, On-Board Unit) that enables V2V and V2I/I2V communications. On the other hand, they have a set of sensors to measure their own status (e.g. fuel consumption) and its environment (e.g. slippery road, safety distance). These sensorial data can be shared with other vehicles to increase their awareness and improve road safety. Finally, a Trusted Platform Module (TPM) is often mounted on vehicles. VANETs is mainly composed by those entities to manage the traffic or offering external services [13]. The most important tasks of the vehicular network is vehicle registration and offence reporting. The following figure shows the general VANET architecture.

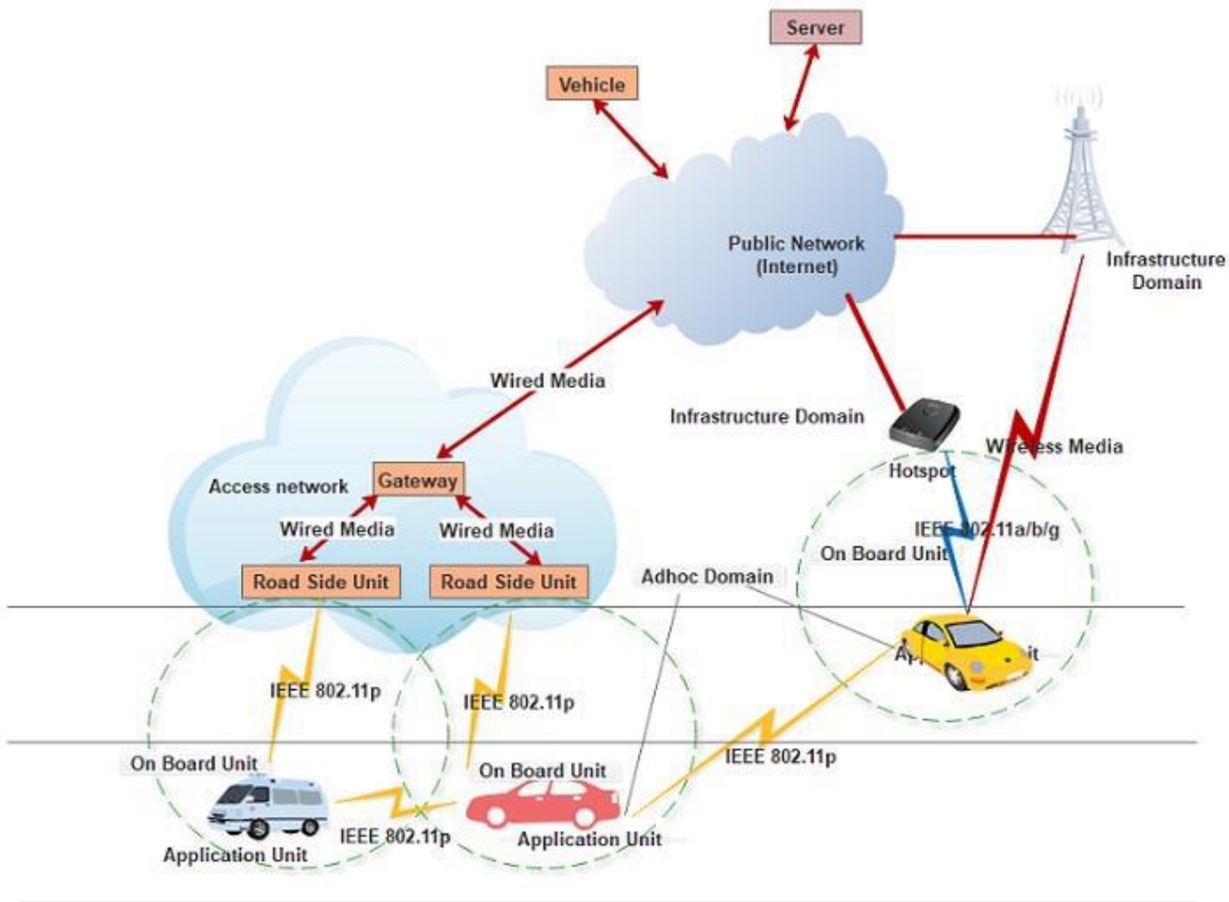

Figure 2.1 General Architecture of VANET [4]

2.2. VANET Characteristics

VANET is a wireless system where nodes are the settled street units or the exceptionally mobile vehicles. In foundation mode, nodes conversation with each other in ad-hoc mode and communicate with fixed hardware on the streets. Thus, the characteristic of VANET system is a mixture of remote medium attributes and the qualities of the different topologies in ad-hoc and foundation modes. VANET has its own unique characteristics when compared with other types of MANETs, the unique characteristics of VANETs is explained below [14]–[16].

2.2.1. Dynamic topology

VANET topology changes quickly, since the vehicular network operates in a very dynamic environment and unpredictable topology. It may operate in a highway scenario or in the urban environment. The lifetime of the link between vehicles is affected by the radio communication range and the direction of the vehicles. Broadening the radio communication range leads to an increase in the lifetime of the link. The association time or lifetime of the link is very short lived particularly between the vehicles moving in inverse directions compared with case in which vehicles move in the same direction. The rapid changes in link connectivity cause the effective network diameter to be small, while many paths are disconnected before they can be utilized. This topology helps the attack of the whole system, and makes difficult the discovery of malfunction. High speeds typify moving vehicles, especially at the highway leading to rapid changes in network topology. Moreover, driver behavior is affected by the necessity to react to the data received from the network, which causes changes in the network topology.

2.2.2. Predictable mobility

VANET differs from other types of mobile ad hoc networks in which nodes move in a random way. In essential procedure of vehicular communication, vehicles are moving in various directions with different speed. Nodes of vehicular networks are constrained by road topology, layout and by the requirement to obey road signs and traffic lights and to respond to other moving vehicles leading to predictability in terms of their mobility. The high mobility of VANET nodes is the imperative feature. The high mobility of nodes gives the complex topology to the Vehicular Networks. VANET mobility range is high when contrasted with MANET. Many researchers are being committed to concentrate the effect of versatility figure specially appointed systems and particularly for vehicular network systems.

2.2.3. Frequent Disconnection

The dynamic topology and the high mobility of nodes and also different conditions, for example, atmosphere, because of movement density frequent disconnections of vehicles happened from the system.

2.2.4. Transmission medium Accessibility

In VANET system, transmission medium is air. Regardless of the way that the across the board openness of this remote transmission medium which is one of the huge points of interest in IVC, transforms into the wellspring of some security issues.

2.2.5. Limited bandwidth

The institutionalized DSRC band for VANET can be considered as constrained, whole transmission capacity range is 75 MHz Impediment of utilization in a few nations proposes that these 75 MHz range are not all permitted. The greatest hypothetical throughput is 27 Mbps.

2.2.6. Attenuations

DSRC band has also transmission issues to computerized transmission with such frequencies, for example, diffraction, reflection, scattering, diverse sorts of blurring Doppler Impact, misfortunes and spread deferrals because of multipath reflections.

2.2.7. Restricted transmission control

The transmission power is bound in the WAVE system, which requirements the space that information can reach. This distance and space is up to 1000 m. Also, in certain particular cases for example public safety and emergency it is permit to transmit with a higher power.

2.2.8. Providing safe driving, improving passenger comfort and enhancing traffic efficiency

VANET provides direct communications among moving vehicles, thus allowing a set of applications, demanding direct communication between nodes to be applied over the network. Such applications can provide drivers travelling in the same direction with warning messages about accidents, or about the need for sudden hard breaking; leading the driver to build a broader picture of the road ahead. Moreover, additional kinds of applications could be applied via this type of network in order to improve passenger comfort and traffic efficiency by disseminating information about weather, traffic flow and point of interest information (gas station, shopping malls and fast food).

2.2.9. No power constraints

The power in VANET is not a critical challenge as in MANETs, because vehicles have the ability to provide continuous power to the OBU via the long life battery.

2.2.10. Variable network density

The network density in VANET varies depending on the traffic density, which can be very high in the case of a traffic jam, or very low, as in sub urban traffic.

2.2.11. Large scale network

The network scale could be large in dense urban areas such as the city Centre, highways and at the entrance of the big cities.

2.2.12. High computational ability

Because the nodes in VANET are vehicles, they can be equipped with a sufficient number of sensors and computational resources; such as processors, a large memory capacity, advanced antenna technology and GPS.These resources increase the computational capacity of the node, which help obtaining reliable wireless communication and acquiring accurate information regarding its current position, speed and direction.

2.3. VANETs Communication Standard

Every wireless access and communication protocols of VANETs needs standards to provide the radio access required for the vehicles in order to communicate via V2V, V2I or I2I communication respectively. This is because of the standards simplify the development of new products and help in comparison of competing products. The main aim of these communication standards is to improve road safety, traffic efficiency and to provide driver's and passenger's ease by enabling a set of comfort applications. The following communication standards has presented DSRC and WAVE standard for vehicular networks communication [17].

2.3.1. Dedicated Short Range Communication (DSRC)

DSRC is developed in Europe and Japan in 2003, to support mainly Vehicle-to-Vehicle and Vehicle-to-Infrastructure communications. It is a short to medium range communication service based on IEEE 802.11p standard, which in turn is derived from IEEE 802.11a standard [18].

The aim of DSRC is to support low overhead operations in communication [3]. For VANETs these communications may include traffic information, accident information, road conditions, inter-vehicle safety messages, toll collection, drive through payment and so on. DSRC is majorly used during communication for providing high data transfer with low communication delay or latency.

DSRC is a licensed but free spectrum. It is given free of cost as FCC does not charge its spectrum usage, but to restrict the usage of the spectrum for avoiding the congestion; it needs to be licensed [19]. For example, the use of specific channels and all radio stations should conform to the standard laid by FCC [18].

The DSRC spectrum is divided into seven channels. Each channel is 10 MHz wide. These channels are divided into one control channel and six service channels. Control channel is responsible for broadcasting high-priority messages and management data. Service channels are switched to monitor the control channel and transferring other data.

There are different DSRC standards exists in literature used by various countries like USA, EUROPE and JAPAN [20]. These standards are differ in type of communication, radio frequency band used for communication, number of channels and their separation, data transmission rate, coverage and their modulation.

2.3.2. Wireless Access in Vehicular Environment (WAVE)

Wireless fidelity (Wi-Fi) or Wireless local area network (WLAN) is used to provide wireless access in Vehicular networks to enable Vehicle-to-Vehicle communication or Vehicle-to-Infrastructure communication. WLAN system has less delay or latency but the use of wireless local area network requires additional infrastructure such as wireless adapters and wireless routers that incurs an additional cost for its usage. IEEE 802.11 standards are used to provide the wireless connectivity [20]. WAVE is the standard obtained by combining the whole DSRC protocol stack that includes both IEEE 802.11p and IEEE 1609 standards. The disadvantage of using the traditional IEEE 802.11 in vehicular communication is the overhead generated at the significant rate. For example, to ensure timely vehicular communication, fast data exchanges are required. To address all these challenges, DSRC is combined with IEEE 802.11 standard to become a new standard as IEEE 802.11p, which further combines with IEEE 1609.x to form a universally accepted standard called WAVE [3]. IEEE Standard 1609 is one of the standards of IEEE 1609/802.16e standards. IEEE Standard 1609 defines the communication model, security mechanism, management structure, physical access and overall architecture for wireless communications for basic components (RSU and OBU) in the vehicular environment [21].

IEEE Standard 1609.1-2006 enables the WAVE applications interoperability by describing the major components of its architecture, and further defines storage message formats and command [22]. IEEE Standard 1609.2-2006 describes various security services for the management of WAVE and provides application messages to avoid attacks like spoofing, replay, eavesdropping and alteration [23]. IEEE Standard 1609.3-2007 specifies routing services and addressing mechanism for WAVE system to enable multiple stacks of upper/lower layers above/below WAVE networking services, secure data exchange, defines WSMP as an alternative to IP for WAVE applications. IEEE Standard 1609.4-2006 describes the enhancements made in Media Access Control Layer of 802.11 to support WAVE. IEEE Standard 802.16e enables interoperability among various multi-vendor broadband wireless access products. WAVE standard describes both stationary and mobile devices. Either of RSU, a stationary device and OBU, a mobile device can be a provider or a user of services. The WAVE standard defines applications that resides on the RSU but is aimed to provide access to OBU by multiplexing the requests. It uses Orthogonal Frequency Division Multiplexing (OFDM) to split the signal into several narrowband channels and provide a data payload communication capability of 3, 4.5, 6, 9, 12, 18, 24 and 27 Mbps in 10 MHz channels [18], [24].

2.4. Applications of Vehicular Ad-hoc Network

The optimum goals that is targeted by VANET was to assure that safe movement of the vehicle and passengers by providing early information and timely feedback to that situations. However, to increase the market penetration, other classes of applications such as traffic control and provision of infotainment are also being considered [25].

VANET applications are typically classified into two major categories [26], [27]. They are: Safety related Applications and Non-Safety related Applications. Both categories are explained below.

2.4.1. Safety related Applications

The aim of safety related applications was to ensure safer travel by generating early warnings and timely response to the situations. These applications are used to avoid the risk of road accidents by distributing information about hazards and obstacles. Safety applications can play an important role in avoiding accidents or minimizing the impact of accidents [13]. These applications offer info and support the drivers by sharing information (position, intersection position, distance and speed) between vehicles and RSU for avoiding collisions with other vehicles. Using Exchanging information to detect hazardous locations [17]. According to a study, if the driver gets a warning half a second before the collision, more than half of the accidents can be avoided [28]. There are too many things to consider for the vehicle drivers, like the drivers attention to the traffic management lights, other vehicles, pedestrians, and also following the directions using GPS. Giving full attention to all of this events at once is too difficult for the drivers to give timely attention. Some kinds of safety warning messages, like when a driver is getting ready to make a turn to the right/left might simply look a pedestrian crossing right/left side of the road. This kind of early notification of warning messages helps to reduce the traffic accidents.

Some other kinds of warning systems can also be deployed to avoid the accidents, e.g., work zone warning, stopped vehicle warning, and low bridge warning for trucks. Some safety applications can also be helpful after accident such as to send emergency notifications to nearby emergency responders. Such applications also manage traffic flows and identify alternative routes. Besides warning messages, safety applications are also used to provide assistance to a drive about lane change, navigation and to avoid collisions by applying automatic emergency breaks. Safety applications also guide the driver about speed limit to avoid collisions [13]. Safety applications demand strict time delay bounds. Even a fraction of a second is important in decision making. Thus, the requirement of hard deadline posed by the safety applications requires special handling at lower layers. As network layer is concerned, not much routing is involved in safety applications, because the target audiences for the messages are usually in the neighborhood. Therefore, the messages need not to be sent to nodes more than one hop away. The following are classification of safety related applications. They are: - **Assistance, information,** and **warning messages** [13]**.**

Intersection accident: Collision risk that came in intersections sensed through vehicles or RSUs.

Lane alteration support: Side impact danger of vehicles that changing path is reduced with an unseeing area.

Overtaking vehicle: The risk of third-party exposure to prevent collisions between vehicles in a bypass mode, where a single vehicle, for example a vehicle1 ready to overtake a vehicle 3, whereas additional, vehicle 2 already achieve passing operation on vehicle 3. Crash between 1 and 2 is prohibited when 2 notifies 1 to stay its passing process.

Emergency vehicle: A dynamic emergency vehicle, i.e., a police vehicle, ambulance, can inform adjacent vehicles to empty or leave the required emergency lane. Such useful messages can be replayed by other vehicles or RSUs.

Driving on Wrong way: A car found to be driving in the wrong way, for example, a prohibited address, denotes to this state to other vehicles and RSUs.

Traffic condition: Any rapid transit development detected by vehicles, learns others (vehicles and RSUs about the state).

Signal violation: RSU detect a violation. Information transmitted through a RSUs to all neighborhood.

Collision risk: RSU detects any collision between vehicles that don't have facility to interconnect. RSU broadcast information towards all cars in neighborhood.

2.4.2. Non-Safety Applications (Convenience Application)

Although the main purpose of VANET is to provide safety, however, some non-safety applications are also being considered to increase the market penetration such as traffic efficiency, control management, and some infotainment applications [25].

2.4.2.1. Traffic Control and Management Applications

The main purpose of traffic control and management applications is to optimize traffic flows and to minimize the travel time by avoiding traffic congestions or assist the driver about best route with updated road conditions. This can involve the use of some roadside equipment, e.g., intelligent traffic signals and e-sign boards. Information about the road congestions ahead can definitely help in reducing the congestion and improving the capacity of roads.

Some other applications can also be envisioned such as automated call to emergency services, enroute, and pre-trip traffic assistance. An interesting application is eToll plaza, where vehicles do not need to stop to pay toll fee. Vehicles can communicate with the roadside infrastructure, where it can be recognized and a fee can be charged against its account.

Congestion at road intersections can be handled in an efficient manner using intelligent traffic signals. These traffic signals can adjust themselves in response to the traffic conditions at intersection and can even communicate the status to neighboring intersections. Neighboring intersections can thus display this information on the e-sign boards and adjust their traffic signals accordingly.

Traffic management applications extensively use the roadside infrastructure. Some infrastructure may be available to be used by any user while some will need subscription. For example, eToll infrastructure will require a subscription to offer its services. For these applications, the infrastructure needs to be managed and updated. For these applications to work, the infrastructure with relevant information needs to be managed and controlled. Comfort and Infotainment Applications be managed and controlled [13].

2.4.2.2. Comfort and Infotainment Applications

Besides road safety applications, comfort and entertainment applications are also envisioned for VANETs. These applications aim to provide comfort and entertainment to travelers. Such applications can be further categorized into three types: infotainment, mobile e-commerce, and city leisure information.

The passengers in a vehicle can enjoy the facility of Internet connectivity where other traditional wireless Internet connectivity options (Wi-Fi, Wi-MAX, etc.) are not available. Even in the presence of such options, a node connected to Internet through these options can share its connectivity with other vehicles through VANET.

Peer-to-peer applications can also find their place in VANETs, e.g., gaming, chatting, file sharing, and Web browsing.

Different companies use VANET for advertisements or announcements of location-based sales information; for example, gas stations can announce updated prices or different restaurant can highlight different deals to attract travelers. Beside this, some VANET applications make it easy for travelers to see the nearest service shops or restaurant, etc. The messages sent by such type of applications usually need to be delivered over multiple hops; hence, routing will be involved.

Infotainment applications in VANET can be grouped as peer-2-peer and Internet based applications. These applications are very much useful to provide services such as sharing multimedia files, movies, and songs among the vehicles in the network.

People can connect with the Internet all the time, thereby VANET provides the constant connectivity of the Internet to the users. These applications provide comfort for travelers such as advanced traveler information systems and general entertainment [13].

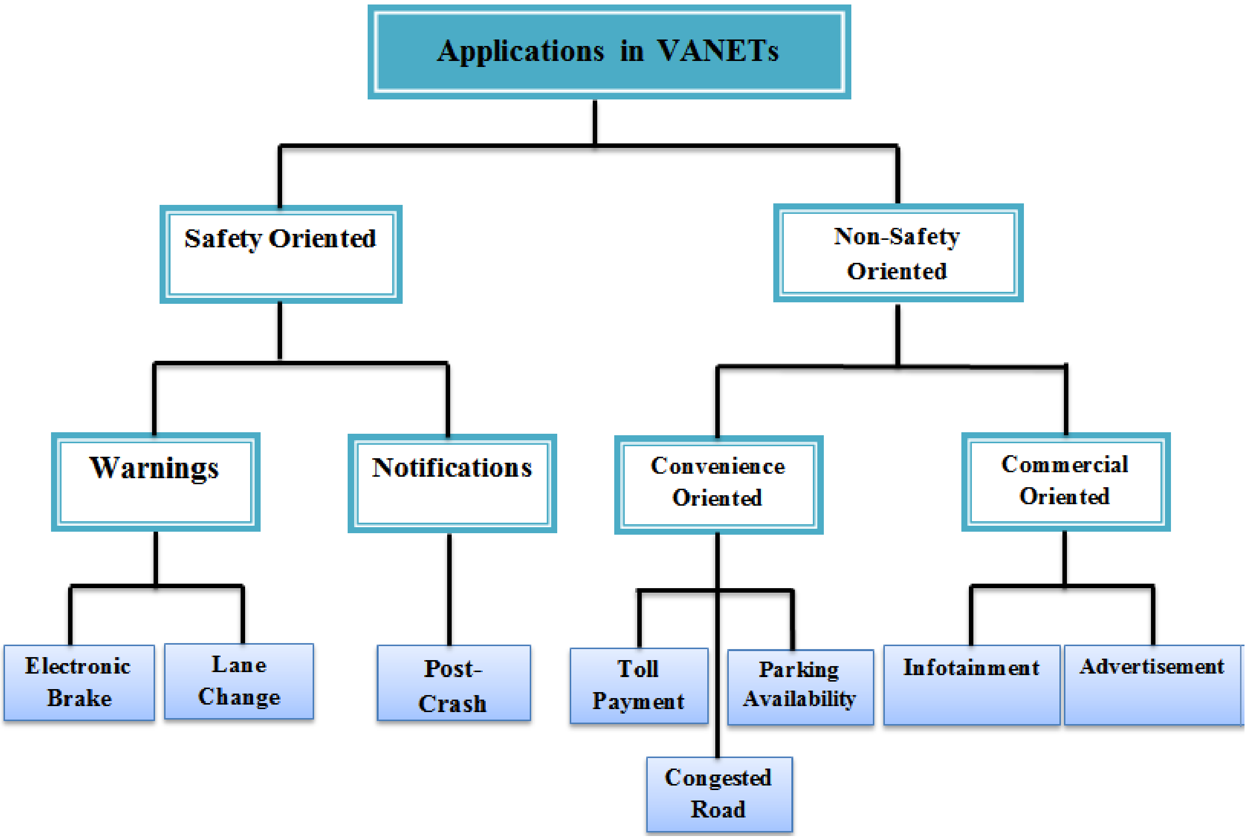

Fig.2.2 VANETs application diagram [29]

2.5. Challenges of VANETs

In the last decade, there is a remarkable progress in the field of VANETs. Regardless of advantages, VANET still suffering from many challenging issues [14], [17], [30]. These are discussed as follows:

2.5.1. High Latency

The message transmitted by the OBU should reach to one or more OBUs within the acceptable time duration in VANET. So that, the driver of receiving OBU may have sufficient time to take necessary action corresponding to received message. Since, VANET does not have any central coordinator for bandwidth management and may results, congestion due to limited bandwidth (10-20 MHz) particularly in high-density area. The fair bandwidth management reduces delay for disseminating messages

2.5.2. Heterogeneous Networks

The network is one of the critical issues, as different countries have different security and privacy policies and differing available infrastructure and implementation by manufacturers. The protocols used by different networks may be different and this may lead to high latency.

2.5.3. High Mobility

VANET has highly mobile nodes. The vehicles move on predefined particular path. Due to high speed the topology changes very rapidly and a node makes connections to RSUs or nearby OBUs of a very short interval. The high mobility rate may cause break-up of ongoing existing connection and establishment of new connection. Frequently disconnection and establishment may cause higher latency. This affects the quality of communication. In addition, it is very difficult to authenticate high-speed moving vehicle. For this, many researchers suggest IPv6 enabled low overhead authentication schemes.

2.5.4. Privacy

VANET has an association between user and vehicle. Privacy concerns should not disclose the driver's location. Furthermore, the journey may involve the financial truncation. VANET should take care of privacy of transitions involved during the journey.

2.5.5. Need of high computational ability

In VANET, vehicles are equipped with large number of sensors and computational resources. The computational ability of these resources, such as GPS, processors, etc., is most challenging issue. Real time computational power helps to obtain current position, speed and direction of vehicle at any moment of time.

2.5.6. Irregular Network Density

The network density in VANET is not same under each RSU. It depends on many factors such as traffic jam, narrow bridges, rural or urban area. In daytime, the traffic may have higher density in comparison to night time. Similarly, urban area, highways etc. may have higher density with respect to rural area.

2.5.7. Cooperation with other networks

In VANETs, the nodes are expected to interact with other nodes, infrastructure and various other applications and services which exist in the network. To provide a good service to the user, the cooperation between these nodes is required in order to provide the information about current weather, traffic conditions and routes available [31].

2.5.8. Signal Fading

The obstacles between two communicating vehicles may lead to fading of signals and results decrease in efficiency of VANET. The obstacles may be buildings or any other vehicle.

2.5.9. Routing Protocol

To manage high-speed moving vehicles, VANET should have an efficient routing protocol that can deliver the messages within the specified time interval to the destination. Efficient routing may increase the reliability, scalability and decrees in latency in message delivery.

2.5.10. Security

Security is the most critical issue of VANET. The security services may lead to secure processing and exchange of messages. The security services include authentication, availability, confidentiality, integrity, non-repudiation, Privacy and anonymity, Data verification, access control, Traceability and revocability, error detection, Liability identification, Vehicle ID Traceability etc.

2.6. Message dissemination in VANET

Message dissemination is a key component of Vehicular Ad hoc Networks (VANETs). It enables the capability of Intelligent Transportation Systems to support safety and infotainment services for vehicles and people on travel. Dissemination in VANETs typically relies on the intelligent election of selected vehicles to act as relay nodes. This is a critical element that serves to avoid broadcasting storm issues or any safety application problem [32]. As a result of the specific features of safety messages, broadcasting may be the only possible means of exchanging messages. Therefore, you may have full coverage of all or any relevant vehicle for the purpose of data exchanging between each vehicles. The transmission of the signal triggers the transfer of a warning message to all vehicles out of the radio transmission range of a single hop [16]. The process of message dissemination determines many different problems because of a unique features of VANETs. Issues like vehicle speed, network size and connectivity between mobile nodes is another problem which severely affect the entire process like latency requirements. According to different researches there is a mechanism of information delivery mechanism. In this case, all the necessary information about the status of the vehicles has to be discovered and shared between vehicles [33]. According to different studies, many of the research distinguished the following data dissemination approaches:

Opportunistic data dissemination approach: According to this approach information is pulled from other vehicles or infrastructure as a target vehicle encounters them opportunistically.

Vehicle-assisted data dissemination approach: A vehicle carries information with it and delivers it either to the infrastructure or to other vehicles when it encounters them. This process involves mobility in addition to wireless transmissions in order to disseminate the information.

Cooperative data dissemination approach: Vehicles can download partial units of some content and then share them afterwards to obtain the complete content. This method is particularly suitable for content dissemination where the amount of information is rather important in terms of file size.

Generally according to different literatures the main broadcasting approaches relay in to two categories [7], [34] They are described below: -

2.6.1. 1-hop message dissemination (single-hop)

The way of information exchange in single-hop message dissemination scheme is via the vehicle which is near the range of the sending nodes. The information received from other vehicles is not rebroadcasted by the receiving vehicle [34]. Dissemination schemes using single-hop safety messages provide local information, hence requiring additional aggregation algorithms to be feasible in safety applications for covering a wide area [7]. These operations increase the computational overhead of the applications, which may delay the detection and notification of dangerous situations, thus making them unsuitable in many scenarios.

2.6.2. 2-hop message dissemination (n-hop)

In this dissemination scheme when a vehicle detects emergency situation, the vehicle inform to its neighbour vehicle and the message should be rebroadcasted to announce the other vehicles which is not in the transmission range of the source node. As VANET is designed to support safety application, the information is expected to be received by all the vehicles.

In VANET, message dissemination is critical issue to quickly inform vehicles about problems which may have positive or negative effect on the neighbour nodes. There are different classification of multi-hop message dissemination schemes as described below to reduce or probably eliminating the negative effects that may happen to the nodes which is in the range of the vehicular networks [34].

Flooding: this is one of the dissemination scheme in which nodes can simply rebroadcast when they receive message. Here when N numbers of nodes are in the network they simply rebroadcast for farther coverage of messages. When vehicles or RSU receive a message which has to be broadcast, initially they check whether the packet is new. If it is new, they rebroadcast; otherwise they discard. Since every node forwards the message, it leads redundancy. The redundancy depends on the density of vehicles found in the transmission range.

Counter-based dissemination scheme: is part of flooding based scheme sometimes called limited flooding. According to this If counter $c \geq$ (threshold) for a received message, rebroadcasting is not allowed for that message.

Beacon: According to this, beacons are periodic messages sent by vehicles to exchange information about their positions, speed, and other basic information's. Those messages have low priority than the alarm messages. Those messages are disseminated in one hope fashion; they are not further rebroadcast by the neighbour nodes.

Distance: according this method, the rebroadcasting of the message depends on the distance between the sender and the receiver. In this dissemination scheme rebroadcasting is not suggest when the separation distance is minimum in order to cover large coverage.

Store and Forward: In this kind of dissemination technique when alert message received by anode, the node store for some time till it gets other node in transmission range. According to this technique a vehicle usually waits to rebroadcast the message until a new neighbour is found. This way mostly used in sparse network scenarios.

Probabilistic: According to this scheme it depends on the probabilistic distributions to determine the probability of broadcasting a given message, depending on the conditions of the transmitting vehicle. Most of the schemes that designed based on this scheme use the Gaussian or the uniform distribution to associate a probability to each message or vehicle.

CHAPTER THREE

3. RELATED WORK

In chapter 2 we have discussed the different ways of data dissemination of vehicular networks depending on different studies. Depending on the different view of the researchers about vehicular network technology, the negative effects about the status of each node and the environment over the networks can be reduced by using standardized mechanisms. There are different problems of VANETs message dissemination which is the critical part of this network, and it needs better enhancement. The reason why message dissemination is the issue that need improvement is that the characteristics of the VANETs like frequent disconnection of nodes, highly mobile, and dynamicity of the topology. These characteristics of VANET network comes with challenges, that is why the enhancement of safety message dissemination is needed because of we need immediate reaction to the emergency event happen to the network. In this chapter we are going to discuss many investigations of message dissemination studied by different researchers. Safety information exchange enables life critical applications, such as the alerting functionality during intersection traversing and lane merging, and thus plays a key role in VANET applications. They are discussed below by classifying them to broadcast based message dissemination scheme, Cluster based message dissemination and Bloom Filter based message dissemination.

3.1. Broadcast based Message Dissemination Scheme

In vehicular ad-hoc networks, safety related information always operate based on wireless channel dissemination since emergency messages like accident and traffic load need to be delivered to all neighbour vehicles. Sometimes VANET nodes that is used to detect emergency events only need to disseminate the emergency messages to their neighbour vehicles within the transmission range. In such case, the MAC protocol will become the dominant component that determine the efficiency of message dissemination. And the design of this protocol is the very fundamental challenges in the network with unique characteristics (i.e. VANET) like constantly moving nodes in the networks. The messages may be limited to unexpected delay due to the medium access contention and medium access delay. Besides delay is another serious problem for message disseminations at the MAC layer in the vehicular networks, where a single message loss due to channel overhead results in very hazardous accident or traffic load. In addition to the MAC layer issues, the network layer plays a major role in end-to-end delay performance in vehicular ad-hoc networks [35].

According to recently investigated researches regarding data dissemination which is usually employed in VANET is merely multi-hop broadcasting schemes. In case of safety messages multi-hop broadcast of the information is required to assist remote vehicles to take good driving decisions. Following multi-hop message dissemination, how quickly we select next hop for message dissemination is very important to improve the delay issue of the network. For safety related applications, message dissemination delay and the communication overhead is the main cause for a terrible traffic accidents. Thus the latency of message dissemination should be minimized. Multi-hop message disseminations in VANETs over flat network topology which is not suitable due to the limited wireless communication range is proposed in [36]. This dissemination mechanism is always the cause for broadcast storm problem which comes with several message redundancy and waste of the limited channel resources of VANETs. More recently, the broadcasting scheme to propagate the emergency messages in VANETs is proposed in [36]. But, this work is still facing broadcast storm which is the fundamental challenges in VANETs. Broadcast storm disturbs the network communication, because of large size of beacons exchanged, topology used and frequently changes the network topology. In wireless networks like VANET which have unique characteristics the neighbor nodes information is the most basis for applications like message dissemination and clustering. More specifically, for highly dynamic network topologies the neighbor information is the main research problem particularly while the collection of n-hop information is needed. This particularly holds for highly dynamic wireless networks like VANETs, the protocols need to maintain as accurate as possible 1- hop 2-hop or n-hop neighbor information [37] [38]. The RTS/CTS protocol combined with acknowledgement (ACK) protocol is proposed in which the focus of the investigation targets is to avoid hidden node problem as well as assuring system reliability by ensuring messages delivery. In this paper each node that receives a request from a sender sends a clearness packet and waits for the data. At that time when recipient receives the message, it guarantees the receipt by replying to the sender with ACK [21]. Despite the assurance of reliability of message delivery, using this four handshaking protocol needs time. Whereas this is not suitable for dissemination of safety messages that need to be delivered quickly. Using RTS/CTS protocol between all the nodes comes with the problem of packet congestions, which in turn leads to the broadcast storm problem.

Time slotted multi-hop broadcast approach is designed to reduce the number of required transmission nodes. This approach works by selecting some of the nodes to be the potential relay nodes, to avoid the broadcast storm problem. It works by focusing on the dividing the roads into segments with fixed lengths. Every node can set to which segment it belongs and calculate a distance between its position and its destination which is in the segment [21]. The results of this approach assures the reliability of message dissemination by allocating separate timeslots to the emergency message including a short time for acknowledgment. At the same time messages collision is avoided. The approach somewhat efficient on the reduction of collision possibility. Thus, timeslot scheme can only reduce messages' collision probability but cannot guarantee fast forwarding of the warning message which is not suitable for emergency message transmission. Context aware and class based dissemination architecture for vehicular networks over 1-hop and 2-hop neighbor information to support ITS proposed in [39]. This approach used rely on hello messages which is used to let the vehicles become aware the status of each other. This strategies technically specifies about small 1-hop broadcast that is used to deal with congestion control [21], [40]. But, the proposed solution still have limitation of large size of beacons as often, which is not suitable for highly dynamic networks like VANETs. Large size of beacon is indirectly the cause for inefficiency of message delivery delay which have serious problem on the number of informed nodes. Thus, the approach proposed in this investigation is not suitable for safety message dissemination.

In broadcast approach or multi-hop scenario, it is challenging to deliver such emergency messages timely and reliably. This is because of the characteristics of decentralization, high mobility and hidden terminal problem in VANETs.

3.2. Cluster based message dissemination scheme

In relation to some issues and challenges which is caused by special characteristics of VANETs, a number of researches are proposed as a solutions to make the vehicular networks to organize by themselves creating dynamic clusters. The approach which targets different region of the network is proposed depending on distributed and dynamic data dissemination protocol in [41]. According to this investigation the proposed protocol includes two main parts. The first one is geo-casting initialization which employs the path sharing key landmark to minimize the total information dissemination time. The second is used to divide each target regions into many small regions to decrease the data redundancy. The proposed scheme can reduce the probability of data redundancy and packet loses. But, the scheme do not consider the delay time of message dissemination in the risk area, which is not suitable for safety message dissemination that may cause big crisis on the human life and traffic conditions. Another investigation for VANETs is researched using hybrid backbone based clustering algorithm designed in [42]. The proposed algorithm specifically focus on creation of cluster heads by considering the number of links and mobility of the nodes. While the process of cluster formation, the approach considers the nodes degree of connectivity initially built as a backbone which is designated as leadership. So that the management of cluster head election and reorganization of cluster is done by the node which is designated as leadership based on aggregate speed of the nodes. This management method which is proposed in the above approach which is not effective for the emergency message because of the communication delay during the process of cluster selection. The approach which considers mobility based clustering scheme for vehicular ah-doc network is proposed which uses affinity propagation algorithm in distributed manner to form clusters [43]. The algorithm which is used to create the cluster considers different factors, such as average duration of the cluster head, cluster member, rate of cluster head changes and number of clusters in the network. But, this paper do not consider about the size of messages exchanged to create cluster and the mathematical complexity of the algorithms used over different networks which is the cause for broadcast storm. Another scheme which is named as analytical hierarchy process using clustering for message dissemination in VANETs is proposed in [30]. According to this research they used clustering to reduce broadcast storm problem. Despite the advantage of this investigation they are still using large beacon size that is the major cause for communication delay of the nodes. So that, this approach is not effective in case of dissemination of emergency messages in such networks which have uniquely challenging characteristics like VANETs.

A strategy which prioritize data handling before creation of cluster for the sake of dissemination is proposed in [44]. This strategy first handle data before transmission and the original message will be optimized by targeting the reduction of packets exchanged. According to this paper, the construction of stable cluster is done after data is optimized. As proposed in this paper the strategy is selected to improve the message delivery time and to assure the bandwidth consumption. The approach based on different parameters such as transmission period, connectivity degree, and the link life time validity. Since data sharing is an important process in VANETs this approach tried to use the routing phase among clusters. Since the performance of data dissemination in VANET is directly related with the mathematical computation of the approaches. The delay time it takes to deal with all the strategies proposed in this paper, it is not effective in case of safety message disseminations.

3.3. Bloom Filter based message dissemination scheme

The first work using bloom filter is proposed in [45]. This approach used the bloom filter to lower the algorithmic complexity for finding a connected set in an ad-hoc network. The study reduced the algorithmic complexity of prior work comparatively by using bloom filter operations. But, the evaluation of the algorithm shows that the amount of received nodes and transmission overhead still remain the same. Another lowering algorithmic complexity is studied by using intersection of Bloom Filter in [46]. This approach causes the loss of packet because of the intersection operation used.

The use of Bloom filters has also been investigated for multi-hop message dissemination in general networks[45] as well as in VANETs [47]. A message dissemination protocol using Bloom filters over neighbor information has been proposed. In this approach, for each message to be forwarded a Bloom filter has to be included which is the limitation on beacon size that causes communication delay [11].

Considering routing and data discovery, different protocols have been proposed using Bloom filters in wireless sensor networks [48], [49] yet, their performance is limited to rather stationary topologies. Moreover, Bloom filter structures are also used in wireless networks for routing in hierarchical topologies [50], or by using aggregated forwarding information for geographical routing [51].

More recently, the neighbor ship management using Bloom Filter for inter vehicle communication, going one step further is proposed in [10]. This study focus on efficient neighbor management algorithms to decide when to add which neighbors into the neighbor table. This scheme uses the information to efficiently choose fitting nodes from that neighbor table to rebroadcast the message. They used 2-hop neighbor node to decide when to add next hop to disseminate the message. This study decreased the transmission overhead by reducing size of beacon to be exchanged among each nodes, but the network topology used is flat. Since there is a limitation on flat topology for VANETs which only considers about the next 1-hop to forward which may globally not suitable for the next hop. There is the problem of undesired message propagation direction which only follows the next hop after 1-hop.

In this paper, we are going to investigate the message dissemination scheme which uses Bloom Filter integrally with clustering for VANETs. Our proposed scheme more specifically study the characteristics of Bloom Filter for the management of neighbor node information. We use the neighbor information for the purpose of cluster formation and message disseminations to reduce the communication overhead by considering message propagation direction and in range of each node neighbor information.

Comparison of different related work of safety message dissemination scheme

Approaches	Dissemination Strategy	Scenario	Objective	Assumption/ requirement
BBMDS	Broadcast based	Highway, Urban	Message Dissemination	Next Hop
CBMDS	Cluster based	Highway, Urban	Message Dissemination	Cluster formation
BFBMDS	Bloom filter based	Highway	Message Dissemination	Neighbor Table

Table 3.1. Comparison of different related work of safety message dissemination scheme

To generalize the above table, different type of safety message dissemination scheme is analyzed. All this scheme have their own contribution to the area of VANETs and also have their own limitation. Most of the scheme which uses simple broadcast technique which is more limited to sparse network, sometimes it is too difficult to use for safety message dissemination because of communication delay to deliver the message. Due to this limitations some improvement is needed to handle or to solve the problems of the above review we tried to address the problem by using the new scheme which uses bloom filter based clustering.

In this study to achieve the aim of our investigation we modified the way of collecting neighbor node information, which is every node can create a table of in range nodes and generating bloom filter for the nodes in the table is designed. This mechanism uses a probabilistic data structure called as Bloom Filter integrally with clustering. Upon the designed algorithm which integrates bloom filter with clustering message is disseminate to the relevant nodes of that network.

CHAPTER FOUR

4. PROPOSED SOLUTION

4.1. Introduction

As we have discussed in details throughout the above chapters, different message dissemination approach is proposed by many researchers. We have analyzed and reviewed the most researches related to our study. The study have tried to improve problems of VANETs focusing on channel overhead. As a number of approaches investigated by different author's increases, there is also many novel ideas that comes throughout the techniques investigated as a solution. Our investigation addressed the problems of the safety message dissemination of VANETs by improving the number of informed nodes ratios. So to improve the number of informed nodes of VANETs the probabilistic data structure which is called as Bloom Filter is used integrally with clustering techniques is proposed for VANET communication. The main contribution of this paper is to enhance message dissemination schemes in vehicular communication in case of the safety message notification to avoid more emergency issues and hazardous cases in VANETs.

4.2. Architecture of the proposed scheme

The architecture explain the overall components used for the message dissemination techniques and the general way of communication in Vehicular networks. This architecture is composed of the proposed solution components and different network layers of the general network of Vehicular Networks communication standards which have their own purposes for the exchange of messages by dissemination of packets among the nodes.

In this architecture nodes and RSU is used depending on the emergency data dissemination is needed in the network within the VANET network. At the moment message dissemination is needed the data transmission methods taken is decided depending on the general algorithm of local components of TCP/IP layers used for message transmission purpose. The standards used for message dissemination is also general in our cases too, which is WAVE and IEEE 802.11p because of these standards is the common techniques used for safety message dissemination too in VANETs and general communication of ad hoc networks.

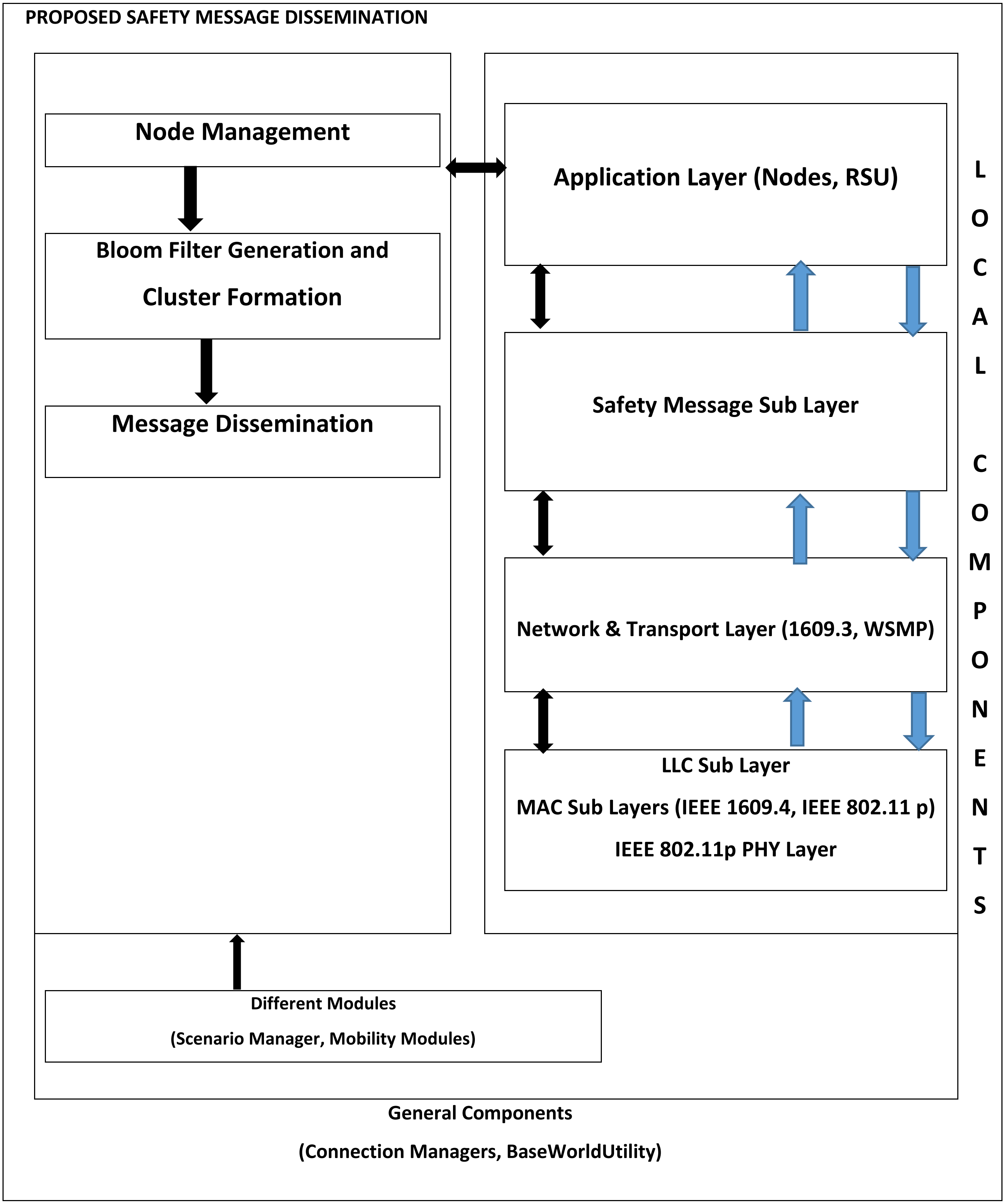

Figure 4.1. General Architecture of the Proposed Scheme

The above Figure 4.1 shows that the general architecture of the proposed schemes which is safety message dissemination using Bloom Filter based clustering in VANETs. The proposed scheme uses the local components of TCP/IP layers used to be included for communication in VANET that takes advantage of both nodes and RSU which is useful to collect neighbor node information's for the design of safety message dissemination. The message dissemination is mostly affected by the characteristics of vehicular networks, which directly have negative effect on the number of informed nodes in the network. Our cases also shares the same flow of TCP/IP communication flow of different investigations and simulations used which is two different components are used to implement the design of the safety message dissemination schemes proposed. They are: General component and local component [34]. General Component shows the public information about the whole network. It contains connection manager, obstacle manager, radio manager and Base world utility.

BaseWorldUtility: is the basic utility module for the whole network and it provides utility methods and information's used by the whole network.

Connection manager: is the module used to control all connection related information. This module is the central module which coordinates the connection between all nodes and it periodically communicates with the mobility module and channel access.

To disseminate one data each node (vehicle and RSU) have IEEE802.11p Physical layer which is specifically designed for VANET and they have IEEE802.11p and IEEE1609.4 MAC layer for disseminating information by using MAC.802.11p MAC used for assigning the MAC address for each node and IEEE1609.4 MAC used for channel allocation. Safety information in VANET relay on the MAC layer [20], [22], [23].

We use WAVE application and network layer for our dissemination scheme. The message sub layer used to incorporate the emergency message generated by our algorithm. The flow shows the new scheme gets MAC address from IEEE802.11p MAC sub layer and the MAC sub layer contains additional modules listed in the Figure. Then the algorithms in the new scheme install in OBU and RSU as application type. Wireless access in a vehicular environment (WAVE) is used for our cases too, since it is the standard obtained by combining the whole DSRC protocol stack that includes both IEEE 802.11p and IEEE 1609 standards [1], [34]. Because of there is problem using traditional IEEE 802.11 in VANET communication standard IEEE 802.11p is used in our scheme to address this problems. And IEEE 802.11p combines with 1609.4 to form accepted standard which is WAVE.

IEEE Standard 1609.4 defines the communication model and overall architecture for wireless communications for basic components (RSU and OBU) in the vehicular environment [23].That is why 1906.4 MAC extension sub layer is used in our case.

IEEE Standard 1609.3 is used at network layers of local components of VANET communication standards to address mechanism for WAVE system and also to enable multiple stacks of upper/lower layers above/below WAVE networking services, secure data exchange, defines WSMP as an alternative to IP for WAVE applications [26]. The same is used in our cases too.

So the flow of data exchanging in the proposed scheme will takes place as described above from source nodes to destination nodes of the local network as shown on the above figure 4.1 of the proposed general architecture.

Generally the information is exchanged as follows: At the application layer source node initiates safety messages to disseminate for the destination node, sent to message sub layer and then the network and transport layer will add its header file to the messages and passed to the IEEE 1609.4 MAC layer extension to add the channel access to the data, and finally passed to IEEE 802.11p MAC layer with header file of that data. Finally the data is sent to the PHY and sent to destination or broadcasted depending on the proposed algorithm of the proposed scheme which is BFBC scheme.

4.3. Proposed Message Dissemination Scheme

As explained in the above chapter (chapter 3) the proposed scheme uses the probabilistic data structure that is called as Bloom Filter targeting improvement of message dissemination efficiency in VANETs. Since message dissemination is the very promising application of VANET, this investigation specifically focuses on the safety message dissemination improvement over highway scenario. The proposed dissemination scheme specific targets is to provide the solution to the effective information sharing between the nodes of the VANETs by minimizing collision, overhead and data loses among the nodes of the networks. Our scheme uses the probabilistic data structure which is called Bloom Filter to improve the number of informed nodes within the minimum time by reducing the channel overhead. The dissemination of safety messages is very critical because of the uniqueness of VANETs or network topology is changing frequently and rapidly, which leads to data loss. So, it is necessary to investigate new techniques for the enhancement of safety message disseminations in VANET to avoid more emergencies and hazardous cases. In this case, we have proposed a new strategy, which specifically focuses on neighbor node management before the emergency events happen in VANETs. Up on the neighbor management the bloom filter of each mobile nodes will be generated. This study uses clustering upon the Bloom Filter techniques used in this study while the safety message dissemination is needed. Depending on the parameters used in this study the information is shared between neighbor nodes by this Bloom Filter based clustering techniques. Partly, this study aims at neighbor node information management that is collected by each nodes/vehicles is used to generate bloom filter. The second part of this study is constructing fast and efficient clusters upon the bloom filter generated to improve the number of informed nodes and to procure efficient bandwidth consumption.

This scheme can inform the necessary information to all the nodes of the network which fits the criteria to receive message that is sent by the source node to reduce the overall risks that happen to the entire network of VANETs. The communication between vehicles can also be used to alert the drivers about a dangerous situation, an accident for instance. As a result, a timely warning will help the driver to avoid an emergency situations to stop or sometimes, a collision.

4.3.1. Node Management

Node management allows all the vehicles which are included in the general network of VANETs to build the neighbor table of the nodes in their communication or transmission range. To make the management of relevant neighbor node best for safety message dissemination through neighbor table management. Each node builds a table with the unique identities of its neighbors of different hopes of in range vehicles. Bloom filter Database is maintained upon the neighbor information's collected by each node.

```
ALGORITHM OF NODE MANAGEMENT
INPUTS: VehID/NodeID
                Position
                Direction
NODES CHECK FOR INRANGE NODE INFORMATION
IF NODES FOUND INRANGE
        FOR EACH VEHICLES/NODES
                CHECK FOR NEIGHBOR TABLE MEMBERSHIP
                        NEW NODE
                        SAME DIRECTION
                        ADD TO NEIGHBOR TABLE
        ENDFOR
ELSE
        NODE NOT INRANGE
        NODE REMOVED AND TABLE UPDATED
ENDIF
```

Algo 4.1. Neighbor Table Management Algorithm

According to the above algorithm (Algo 4.1) designed for neighbor node management is the crucial work of every dissemination scheme. Every node of the network prepares the tables of neighbor nodes with unique identifiers of each vehicles of in range node. To add the node to the neighbor table each node checks for table membership and if the node is new, in range and the same direction of the first nodes. When the new node arrives in the range of one node it will add the newly arrived nodes to the neighbor table of the previously arrived in range for every node. It uses bloom filter hash functions to add the new vehicles arrived. This is done or updated every five seconds constantly in our cases.

4.3.2. Bloom Filter Generation

Based on the Neighbor information collected by neighbor node managements each node generates a Bloom filter which contains the unique identities of the neighbor nodes. This Bloom filter generated will be included in the nodes beacon it broadcasts when the node witnesses some events that affect the safety of the VANETs. In this beacon a fraction of time is included to identify the wireless channel busy time after the last beacon is sent.

The neighbor table is then filled with information about each neighbor node, including its last broadcast Bloom filter, position, distance, and time when the last beacon was received. The Bloom Filters in the neighbor hop table allows the nodes to make probabilistic decisions about the next set of its neighbor nodes, by performing bitwise OR on all of the Bloom filter vectors. In this paper, we focus on what we believe is that the most important application for acquiring the neighbor node information's, choosing a "good set" of in range neighbor nodes. The neighbor information collected will be used for broadcasting the safety messages through the cluster that is created upon the Bloom Filter generated, to cover all of the neighbors. And the set of neighbors or this "good set" should be as small as possible, but contain neighbors with which the next node has a good connectivity.

```
ALGORITHM FOR BLOOM FILTER GENERATION
INPUTS: N_Node
        N_Table
NODES CHECK FOR NEIGHBOR TABLE
IF NEIGHBOR TABLE FOUND
      FOR ALL NODE IN NEIGHBOR TABLE
            GENERATE BLOOM FILTER
      ENDFOR
ELSE
      USE EXISTING BLOOM FILTER
      UPDATE BLOOM FILTER
ENDIF
```

Algo 4.2. Algorithm for Bloom Filter Generation

From the algorithm (Algo 4.2) designed for bloom filter generation, the neighbor information is collected by neighbor table management and up on that collected information the node generates the bloom filter probabilistically. It checks for neighbor table and if there is neighbor set of members in there, it will generate the bloom filter which is full of node information. This generated bloom filter is used as input for the cluster formation easily and timely.

4.3.3. Clustering Formation and Safety Message Dissemination

Clustering is the technique in which large size of networked nodes is grouped into a cluster to make the communication between each nodes efficient. Clustering gained incredible attention because of their good performance. In this thesis, with the aim of solving safety message efficiency during communication among the relevant node of the Vehicular Networks we used the node mobility based clustering algorithm. In addition to the unique characteristics of VANETs, it is difficult to select the relay node to forward the messages among the neighbor nodes without forming some group of the networked nodes. This techniques which is used simply to broadcast a message among the network without grouping the nodes comes with different intolerable decisions to take. That is why the clustering is used in this scheme to pass the message depending on the bloom filter generated by each vehicles as modeled in this research.

This clustering works by selection of a nodes as a head for some specified timestamp. The timestamp used for a single cluster head created is 5seconds which is because of neighbor table and bloom filter is generated every 5 seconds. The technique is used to minimize the total power consumed by DSRC communications by using the information collected by the probabilistic data structure called as a Bloom filter. The bloom filter is generated by each vehicles every 5 seconds and upon that bloom filter generated the neighbor nodes which is included as a member of bloom filter table of the nodes neighbor table is used to create cluster. Because of the neighbor information is very important in case of such networks with unique characteristics like VANETs. So that our proposed module of safety message dissemination takes the advantage of the bloom filter data structure. The target of this way of message passing is to reduce the communication overhead while message forwarding is needed especially in case of safety message dissemination. In this proposed design clustering will be created upon the bloom filter generated for some time interval or specified time which is 5 seconds in our case. According to this investigation clustering technique is started at the moment of some emergency events is observed by the network or one of the node/vehicle. The cluster Head selection is done by checking for the emergency events that happen in the networks. The node which is closer to the emergency zone will be assigned as cluster head by the general network of the designed model. Cluster member selection will be done depending on the bloom filter table of the cluster head selected.

Cluster member will be identified depending on the elected cluster head member of the table which is neighbor table of the cluster head bloom filter generated. Among the cluster member the nodes which is in range of cluster head (200m), behind cluster head in position, and the member nodes with the same flow of direction as cluster head is selected as cluster member. Among the cluster members the node which is far in distance or position (the farthest node among cluster member) from the cluster head bloom filter will be selected as next cluster head. The same process of cluster formation will take place until all the relevant node is informed about the hazardous situations.

Safety message is generated depending on the cluster formed which is abnormal event which results in cluster formation. Then up on the cluster created the message will be disseminated to the node which is good enough and relevant to be informed about the abnormal situations of the network.

Message structures used to disseminate

Road_ID	Cluster_ID	Message_ID	CH_Position	TimeQuantum

```
ALGORITHM FOR CLUSTER FORMATION AND MESSAGE DISSEMINATION
INPUT: Node_Position
        Flow_Direction
       Node_BloomFilter
NODES CHECK FOR ABNORMAL EVENTS
IF ABNORMAL EVENTS FOUND
INITIATE CLUSTERING FORMATION (cluster head)
       FOR THE NEAREST NODE
              SELECT CLUSTER HEAD, CLUSTER MEMBER
              SELECT NEXT CLUSTER HEAD
                            FOR CLUSTER FORMED
                                   GENERATE MESSAGE
                                   DISSEMINATE MESSAGE
                            ENDFOR
       ENDFOR
ELSE
UPDATE BLOOM FILTER
ENDIF
```

Algo 4.3. Algorithm for clustering formation and message dissemination

CHAPTER FIVE

5. Implementation and Result

As explained in the above chapter's safety message dissemination scheme is very useful because of the unique characteristics of VANETs like node mobility and topology changes. As discussed in the proposed model the safety message dissemination scheme using bloom filter based clustering which is used to disseminate safety message by improving the performance of the vehicular network because of the data structure we used to reduce the problems like data loss, amount of informed nodes. For our investigation the sample highway scenario is used as a simulation environment and the implementation work is discussed in this chapter.

5.1. Simulation Tools

For the simulation, we used the VANET simulation tools both network simulator and mobility simulators. Different tools is used by integrating them to get the performance of our dissemination scheme more effective. In our case too like other VANET simulations both components are used by coupling network simulator and road traffic simulators.

5.1.1. Network Simulators

Network simulators are used for the simulation of computer networks and performance evaluation of the network protocols. Network Simulators allow evaluation and study of protocols and applications under different conditions. Compared to the time and cost involved in setting up real hardware they permit users to test and deploy new protocols in a controlled way. There are many networking simulators currently available. Some of them are open source while others are commercial. The most popular open source ones are ns-2, OMNet++, and GloMoSim. Among these ns-2 has been the most popular one and is widely used by the research community. It is a discrete event simulator and its simulation models are written in Tool Command Language (TCL), simulation kernel and various networking components are written in C++. These components are accessible from TCL. Networking topology and statistics are recorded in TCL script files. NS-2 has been extended by different researchers at different places over a period of time. It was extended to include node mobility, realistic physical layer with a radio propagation model and distributed coordination function. OMNet++ is an open source, C++ based discrete event simulator. It can be used for simulation of communication networks and parallel systems. Scenarios in OMNeT++ are characterized by a hierarchy of reusable modules. Modules relationships and communication links are stored in Network Description (NED) files and can be modeled graphically. Simulations can be executed interactively in a graphical environment or as command-line applications. Currently OMNet++ has two major network simulation model frameworks: the mobility framework and INET/Veins framework. The mobility framework enables environment for creating wireless and mobile networks within OMNet++. It provides detailed radio and MAC models including IEEE 802.11a but does not have IEEE 802.11p VANET standard. The Veins/INET framework provides a set of OMNeT++ modules that represent different layers of the Internet protocol stack [52].

5.1.2. Road Traffic Simulators

Traffic simulators generate realistic traffic traces for use as input to a network simulator. The conventional mobility models like random waypoint model (RWP) used in MANETs cannot be used in VANETs because vehicles in VANETs move along defined roads with high speeds without random movement. Traffic simulators generate traces containing node locations and timing details. Examples of widely used open source traffic simulators are VanetMobiSim, SUMO, and MOVE. SUMO (Simulation of Urban Mobility) is implemented in C++. It can handle large road networks. It also simulates micro and macroscopic mobility models. It can import and edit street maps from OpenStreetMap data base. Recent version of SUMO can provide mobility traces to ns3 on real-time basis i.e., ns-3 can use the traces from SUMO as they are generated. MOVE is a JAVA based mobility generator built on top of SUMO with a GUI. MOVE GUI provides user an opportunity to create realistic simulation scenarios without the need of writing simulation scripts and knowledge of about the internal details of SUMO [52].

5.2. VANET Simulators

The VANET simulators are integrated frameworks of networking and traffic simulators. It is been written in C++. For all simulations, we used the vehicular networking simulation toolkit Veins, which couples the SUMO road traffic simulator with the network simulator OMNeT++. We used synthetic but very realistic road traffic modelled by SUMO in favour of road traffic traces since it allows us to easily control the scenario in terms of traffic density. We first configured a six-lane freeway of which the network simulator used 5km of which is two way vehicular movement. We collected protocol performance metrics in a Region of Interest (ROI) of 3km to avoid border effects. We used two different road traffic densities of 20, 50 and 100 vehicles/km to model low and high density traffic respectively to conduct our simulation result over highway road.

Veins couples traffic and networking simulator in a single module to provide a integrated VANET environment. The powerful GUI facilitates deployment of vehicles, protocol modules and paths. Graphs and animation results can also be obtained. It can support parallel simulation on multiple machines.

5.3. Simulation Prototype

The following map shows the simulation we use the sample simulation map. The following figure shows the sample simulation map used for implementation.

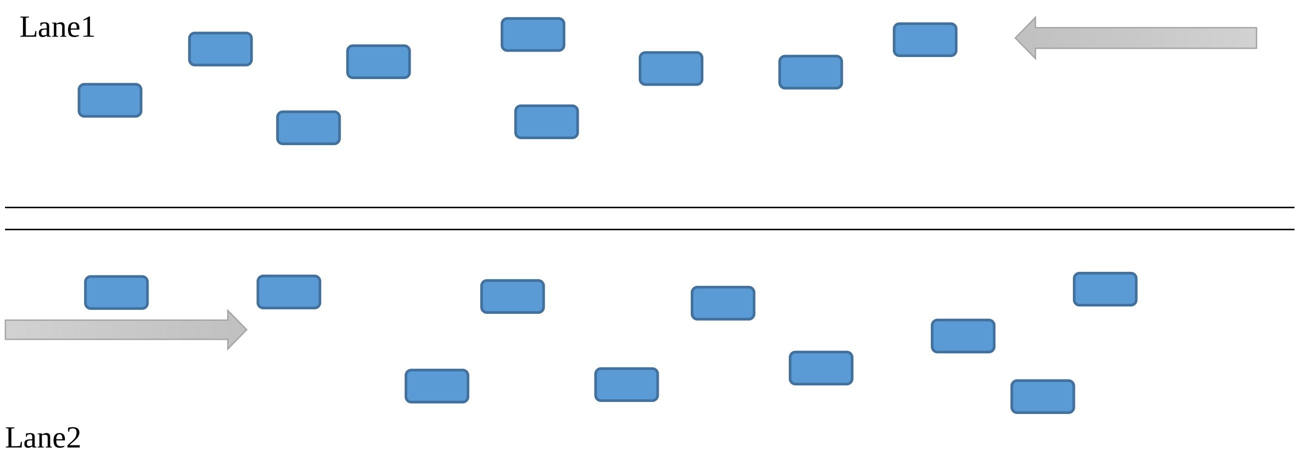

Figure 5.1 Simulation Prototype

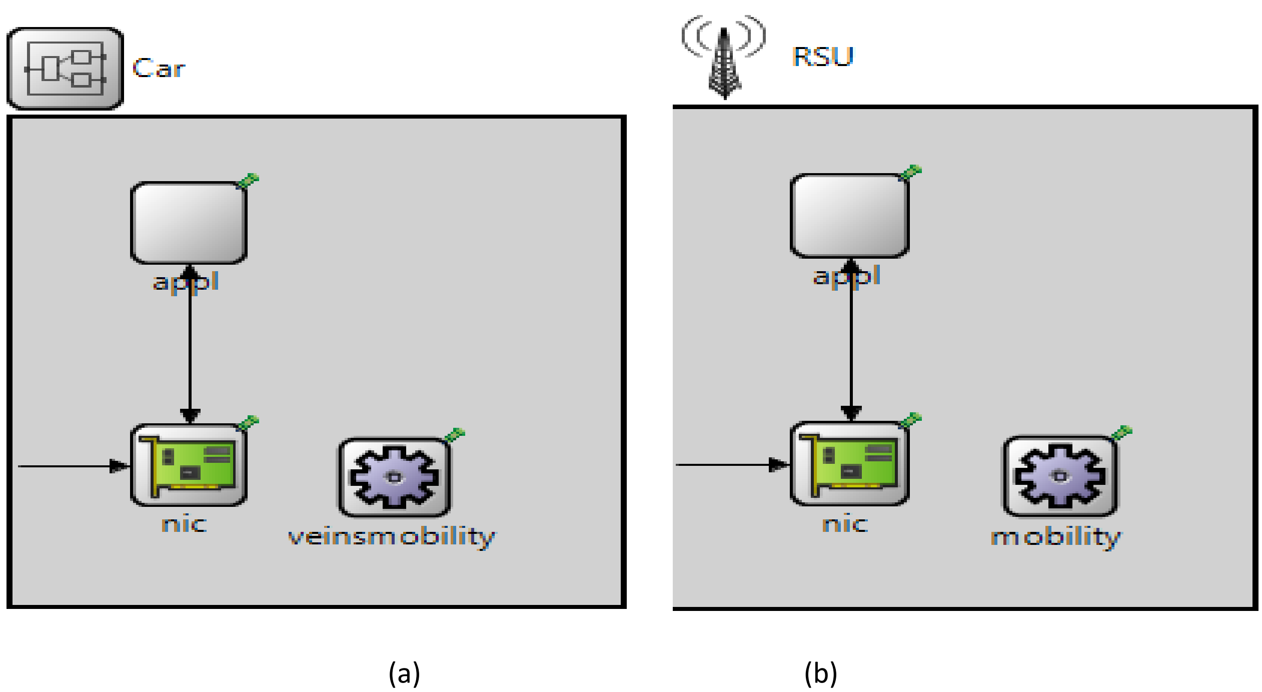

Figure 5.2 Layered configuration of nodes and RSU

5.4 Result and Performance Analysis

For the simulation result and performance analysis of the scheme different simulation experiment with parameters is used. In this section, we use simulation to evaluate the performances of our Bloom filter based clustering safety message dissemination algorithm. We employ different simulation scenarios to show that our algorithm performs better than other schemes. And finally doing comparison with other schemes selected.

For the simulation purpose OMNET++ 5.0, Veins4.7 and SUMO0.25.0 is used to perform the experiment. We have used different parameters with different density of the node which is 20, 50, and 100. As explained in the safety message dissemination scheme physical and MAC layer is used for general message transfer and 600s simulation time is used. The following table shows the parameters used for the simulation purpose.

Parameter	**Value**
MAC layer	802.11p and IEEE1609.4
Physical Layer	802.11p
Number of Vehicles	20, 50, 100
Simulation time	600s
Minimum velocity	10 m/s
Maximum velocity	60 m/s
Maximum transmission range	600 m
Network Size	5km x 5km

Table 5.1 Parameters used for simulation

5.4.1. Simulation and Results Analysis

To evaluate the performance of the designed scheme different related scheme used for safety message dissemination is used for the comparison purpose using different metrics. Those metrics are the number of informed nodes, packet delivery ratio, Overhead, packet drop ratio, and clustering.

Clustering: Cluster node is used in the designed scheme as the message dissemination way. To reduce the number of broadcasting node we used clustering in our design which is formed upon the data structure bloom filter which stores the vehicle member of the network depending on the metrics developed. This method improves the problem that come with simple broadcasting of message used by different schemes like broadcast storm, packet drop, and inefficiency.

CLno = TNofNode / TNoVehCL ----------- - - - - -- - - - - - - - - -- -Eq.5.1

Where CLno is cluster number, TNofNode is total number of nodes in the network, and TNoVehCL is the total number of nodes in the cluster.

Overhead: this is the average number of packets transmitted at each forwarder node during the simulation. When there is high number of packet transmitted over a network there is high number of unwanted traffic. Due to this we use this metrics to measure our scheme and to compare with the existing scheme.

Packet delivery ratio: is the metrics used to measure the percentage of data message which are successfully received by vehicles over a network. It is calculated by the number of received message (MsgRcv) by the number of expected message to be received (MsgExp). Ideally in VANET dissemination scheme 100%data delivery are expected [34].

PDR = MsgRcv / MsgExp ----------- - - - - -- - - - - - - - - - - - - - -- - - - - -- -Eq.5.2

And

MsgExp = TNofNode * Msent ----------- - - - - -- - - - - - - - - - - -- - - - - - - - -Eq.5.3

Where TNofNode refers to the total number of vehicles in the network and Msent refers to the number of sent message during simulation.

Number of informed Node: is the total number of nodes which are notified about the event happened or safety message.

Upon the above metrics we have compared the performance of two related schemes of safety message dissemination to our new scheme. Those schemes are Bloom Hopping and cluster based emergency message dissemination.

Figure 5.3. and 5.4 shows the performance comparison of BFBC and CBEMD in terms of the number of cluster formed and the total number of informed nodes for node 20, 50 and 100 respectively.

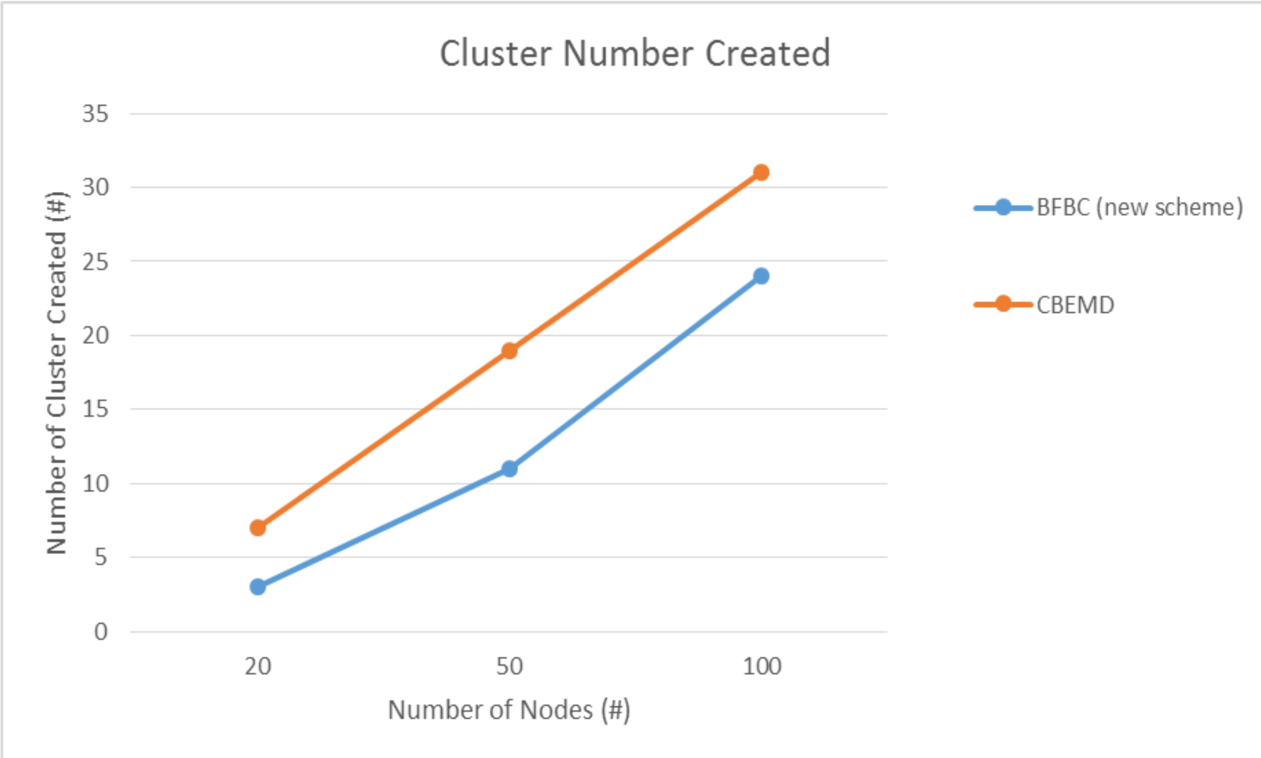

Figure 5.3. Comparison of cluster number created

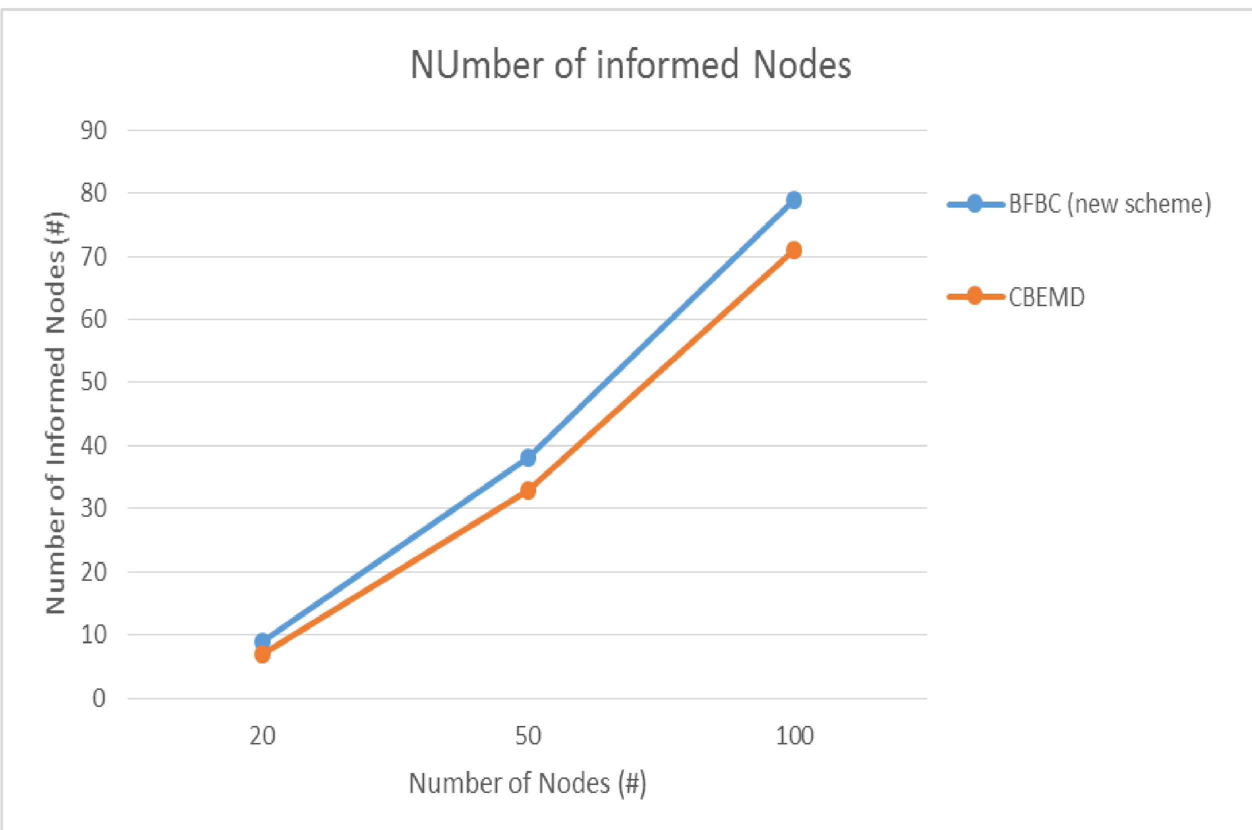

Figure 5.4. Comparison of number of informed nodes

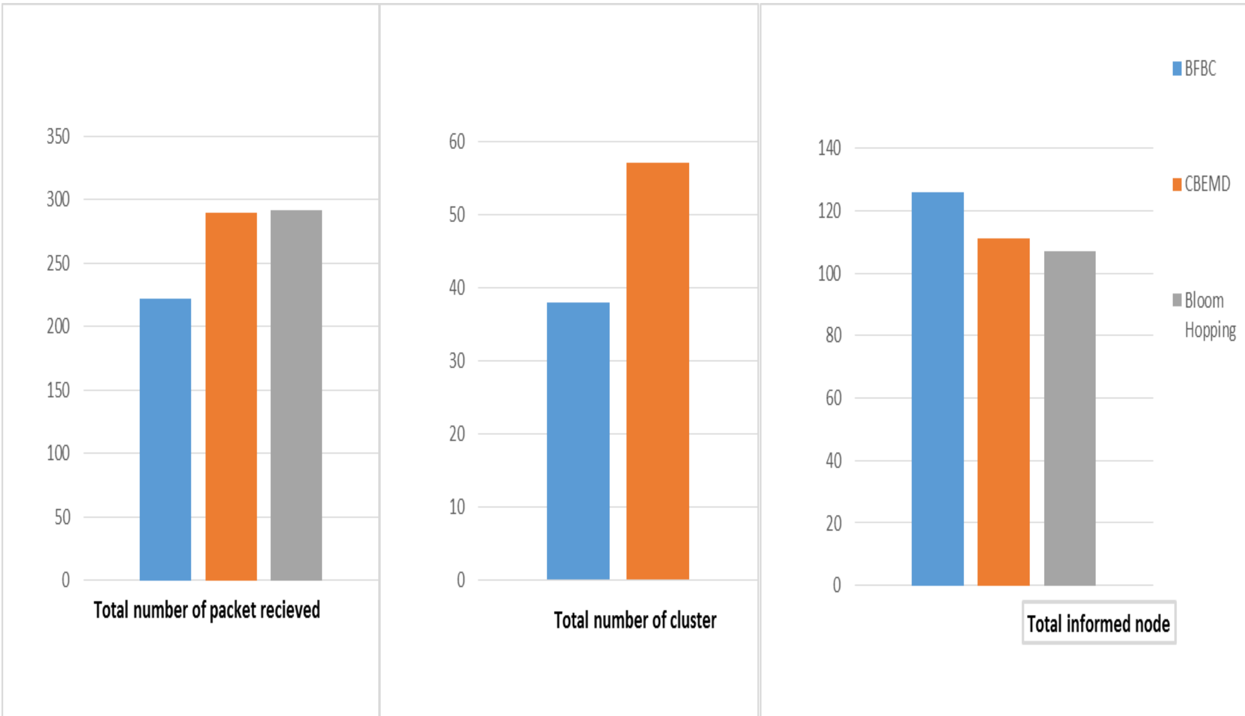

Figure 5.5. Performance Analysis in terms of packet received, cluster and informed nodes

Dissemination Schemes	**Total No: of Nodes**	**Total No: of packets received**	**Metrics**			
			Total No: of informed node	**Packet delivery ratio**	**Cluster No: formed**	**Overhead**
BFBC (the new scheme)	**20**	**5**	**9**	**0.45**	**3**	**6**
	50	**64**	**38**	**0.76**	**11**	**10**
	100	**153**	**79**	**0.79**	**24**	**22**
CBEMD	**20**	**9**	**7**	**0.35**	**7**	**4**
	50	**89**	**33**	**0.66**	**19**	**29**
	100	**192**	**71**	**0.71**	**31**	**57**
Bloom Hopping	**20**	**6**	**10**	**0.5**	**-**	**5**
	50	**82**	**32**	**0.64**	**-**	**28**
	100	**204**	**65**	**0.65**	**-**	**53**

Table 5.2. Analysis of all schemes performance

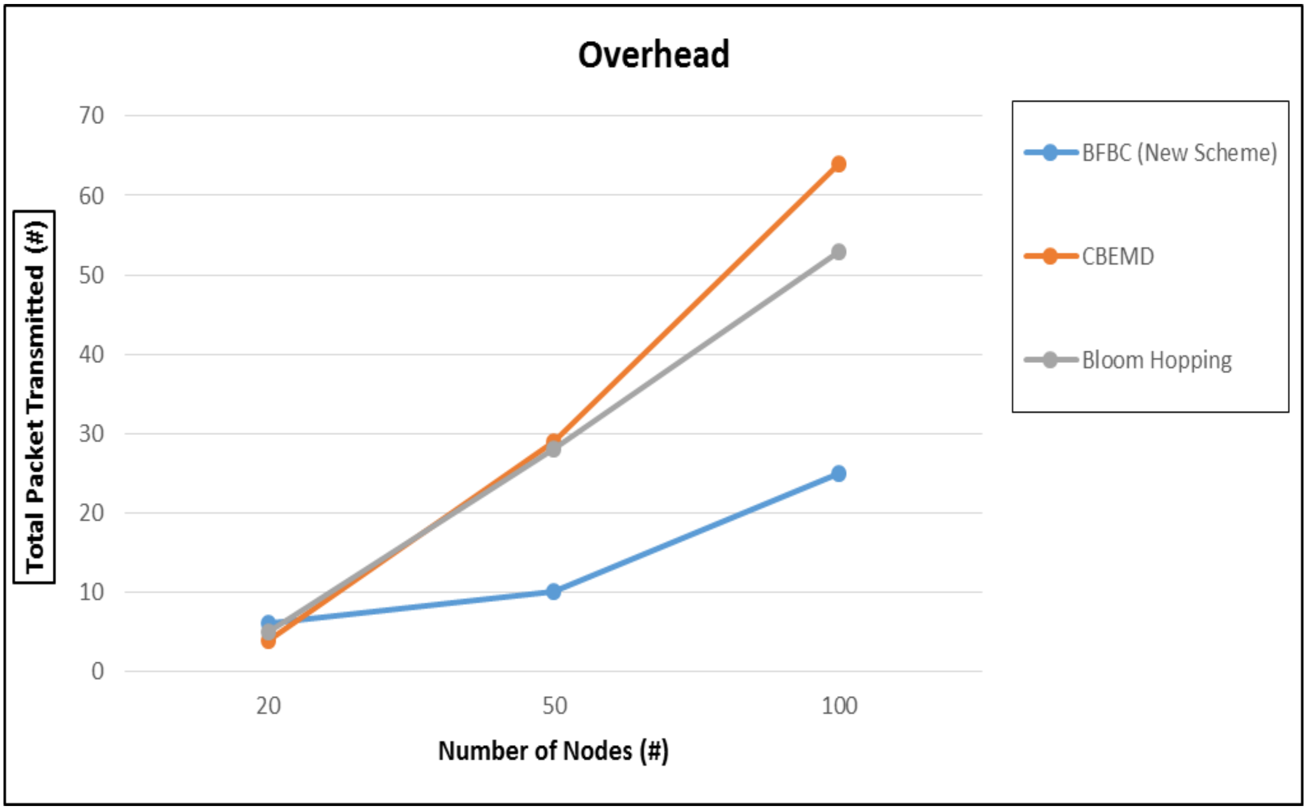

Figure 5.7. Overhead comparison of the schemes with the new scheme.

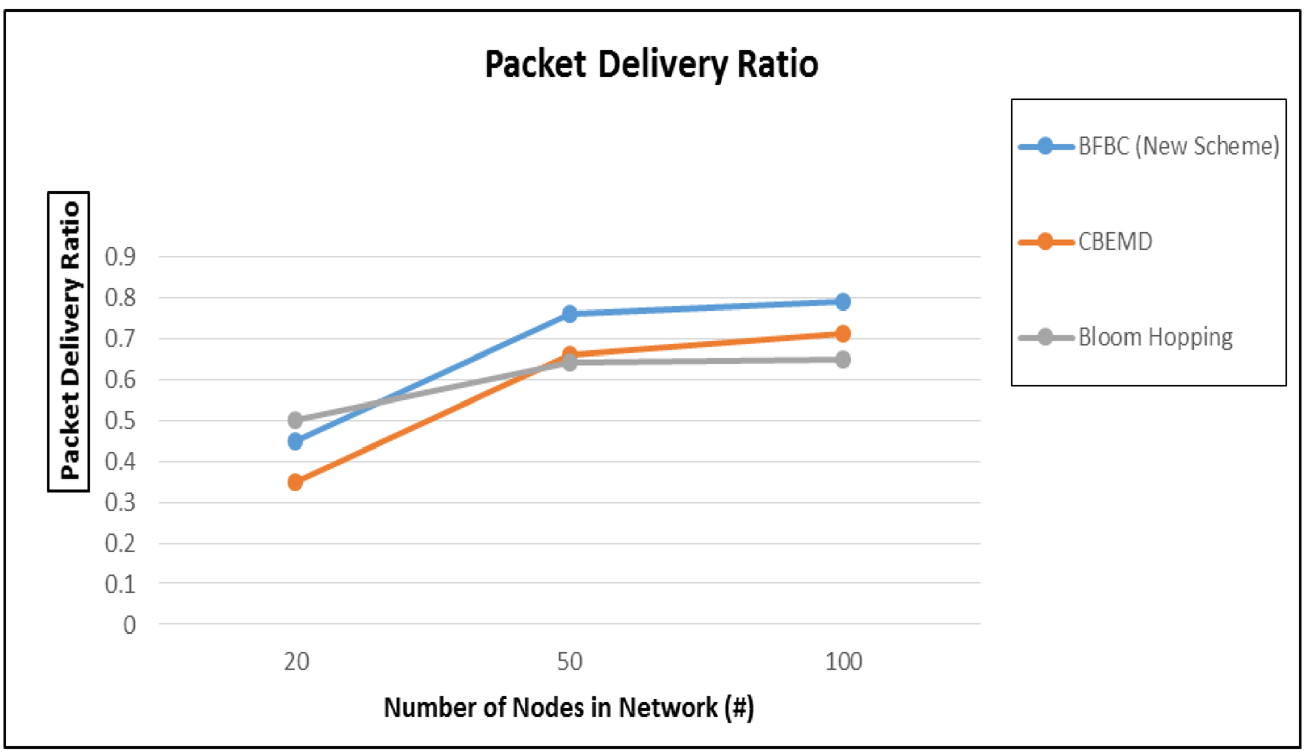

Figure 5.8. Comparison of the three schemes in terms of packet delivery ratio.

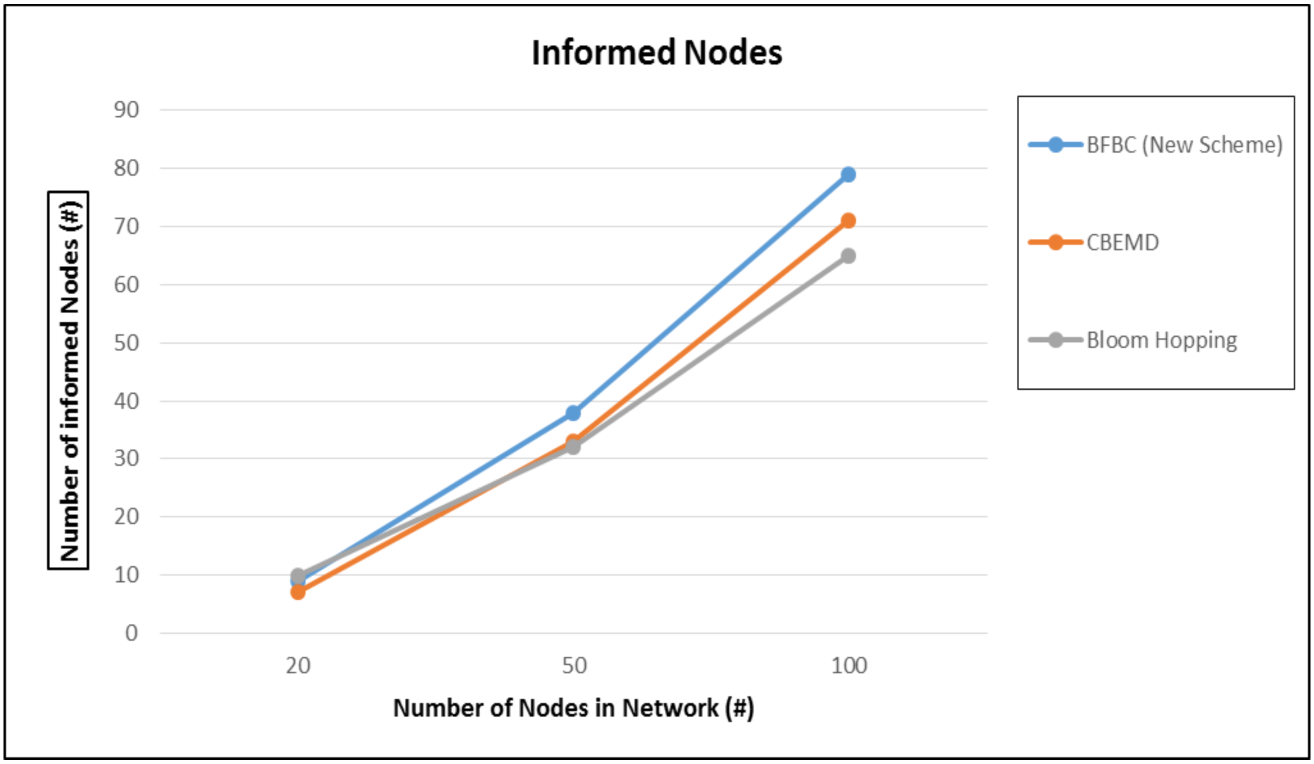

Figure 5.9. Number of informed nodes of the three schemes

5.5. Summary and Discussion

In this chapter presented the performance of the new scheme comparatively with other related safety message dissemination schemes using simulation. And the simulation result is collected by using Omnet++, Veins, and NS2 network simulator. The simulation is evaluated using different metrics of performance evaluation. The experiment included topology generated via open street map data. We used the same topology for all three schemes.

In general BFBC performs much than CBEMD, and Bloom Hopping due to the integration algorithm designed. We measured number of informed nodes, number of cluster created, total packet transmitted, and overhead for BFBC, Bloom Hopping and CBEMD. Improvement can be seen both by overhead, cluster created and number of informed nodes. Comparing all the schemes, we identified that BFBC is much simpler to implement and efficient in case of message dissemination. The performance summary of all the schemes as compared by number of informed node of CBEMD, Bloom Hopping, and BFBC (the new scheme) is discussed in percent (%) respectively as follows: number of informed nodes over 20 nodes (35%, 41%, and 45%), number of informed nodes over 50 nodes (66%, 64%, and 76%), and number of informed nodes over 100 nodes (71%, 65%, and 79%).

Chapter 6

6. Conclusion, Contribution and Future Work

6.1. Conclusion

VANET is a type of MANET which is expected to be integrated with the next generation networks in the coming couple of years. Since VANET is the promising technology that provides a good solution of many problems of ITS is implemented using different techniques especially like simple broadcasting, clustering, to solve the problems of emergency events which is safety application and non-safety application generally. So to provide a better solution to those problems the best scheme is needed specifically for safety message dissemination.

This study integrated Bloom Filter with clustering methods to improve the message dissemination schemes used in VANETs over highway scenario. Firstly, review of related work of message dissemination and characteristics of bloom filter is studied. Depending on the findings of literature review and the characteristics studied, the new scheme uses Bloom Filter for node management and clustering techniques integrally for message dissemination. The focus of the paper is to improve the number of nodes informed about some events happen in the VANETs for safety applications. To reduce delay time to disseminate the message with minimum loss of packets when compared with the prior work. And finally, implementation of the proposed scheme and simulating over simulation environments is done using different simulation tools like OMNET++, Veins, and NS2 network simulators. Finally evaluation of the experiment and analysis of the performance of the new scheme is studied using different metrics comparatively with bloom hopping and cluster based emergency message dissemination scheme. Generally the simulation result and performance evaluation of the new scheme gives us better performance when compared with different schemes over VANETs.

6.2. Contribution

The contribution of this study over VANET environment over highway scenario in terms of safety message dissemination is listed as follows:

New algorithm to create clustering which uses probabilistic data structure is designed.

New scheme which identifies the use of bloom filter both in safety application and clustering is investigated using bloom filter data structure.

New mechanism is used to merge bloom filter with clustering to improve safety message dissemination.

6.3. Future work

This thesis improved some performance of safety message dissemination schemes to follow the events that happen accidentally. This work is effective in case of safety message using bloom filter data structure which reduced packet lose and, improved the performance of the safety applications. As a future work we recommend the researchers to develop the good performing schemes for both highway and all included scenarios like urban, and Manhattan scenarios. This work will be enhanced to the following at the future. It is better if security is considered, better if developed for any VANET scenarios, and it is workable in the general network if anyone use this probabilistic data structure. And also this study will be enhanced to all application of VANETs.

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Appendices

Appendix A: Ned files

*//**FFT.ned** : the overall network definition file for the network*

```
import org.car2x.veins.nodes.RSU;
import org.car2x.veins.nodes.Scenario;
network fft extends Scenario
{
submodules:
rsu[1]: RSU {
@display("p=250,200;b=10,10,oval;r=90");
}
rsu[2]: RSU {
@display("p=350,240;b=10,10,oval;r=90");
}
}
```

***//rsu.ned:** network definition for RSU*

```
package org.car2x.veins.nodes;
import org.car2x.veins.base.modules.*;
import org.car2x.veins.modules.nic.Nic80211p;
module rsu
{
parameters:
@display("i=device/antennatower");
string applType; //type of the application layer
string nicType = default("Nic80211p"); // type of network
interface card
gates:
input veinsradioIn; // gate for sendDirect
submodules:
appl: <applType> like org.car2x.veins.base.modules.IBaseApplLayer
{
parameters:
@display("p=60,50");
}
nic: <nicType> like org.car2x.veins.modules.nic.INic80211p {
parameters:
@display("p=60,166");

}
mobility: BaseMobility {
parameters:
@display("p=130,172;i=block/cogwheel");
}
connections:
nic.upperLayerOut --> appl.lowerLayerIn;
nic.upperLayerIn <-- appl.lowerLayerOut;
nic.upperControlOut --> appl.lowerControlIn;
nic.upperControlIn <-- appl.lowerControlOut;
veinsradioIn --> nic.radioIn;
```

```
}
```

//highway.ned

```
package org.car2x.veins.nodes;
import org.car2x.veins.base.connectionManager.ConnectionManager;
import org.car2x.veins.base.modules.BaseWorldUtility;
import
org.car2x.veins.modules.mobility.traci.TraCIScenarioManagerLaunchd
;
import org.car2x.veins.modules.obstacle.ObstacleControl;
import
org.car2x.veins.modules.world.annotations.AnnotationManager;
network Scenario
{
parameters:
double playgroundSizeX @unit(m); // x size of the area the nodes
are in (in meters)
double playgroundSizeY @unit(m); // y size of the area the nodes
are in (in meters)
double playgroundSizeZ @unit(m); // z size of the area the nodes
are in (in meters)
@display("bgb=$playgroundSizeX,$playgroundSizeY");
submodules:
obstacles: ObstacleControl {
@display("p=240,50");
}
annotations: AnnotationManager {
@display("p=260,50");
}
connectionManager: ConnectionManager {

parameters:
@display("p=150,0;i=abstract/multicast");
}
world: BaseWorldUtility {
parameters:
playgroundSizeX = playgroundSizeX;
playgroundSizeY = playgroundSizeY;
playgroundSizeZ = playgroundSizeZ;
@display("p=30,0;i=misc/globe");
}
manager: TraCIScenarioManagerLaunchd {
parameters:
@display("p=512,128");
}
connections allowunconnected:
}
```

//Parameters

```
package org.car2x.veins.nodes;
```

```
import org.car2x.veins.base.modules.*;

import org.car2x.veins.modules.nic.Nic80211p;

module Car

{

parameters:

string applType; //type of the application layer

string nicType = default("Nic80211p"); // type of network
interface card

string veinsmobilityType =
default("org.car2x.veins.modules.mobility.traci.TraCIMobility");
//type of the mobility module

gates:

input veinsradioIn; // gate for sendDirect

submodules:

appl: <applType> like org.car2x.veins.base.modules.IBaseApplLayer
{

parameters:

@display("p=60,50");

}

nic: <nicType> like org.car2x.veins.modules.nic.INic80211p {

parameters:

@display("p=60,166");

}

veinsmobility: <veinsmobilityType> like
org.car2x.veins.base.modules.IMobility {

parameters:

@display("p=130,172;i=block/cogwheel");

}

connections:


/**
```

```
* \file ClusterManagerLayer.h
*/

#ifndef CLUSTERMANAGERLAYER_H
#define CLUSTERMANAGERLAYER_H

#include <Scene/singlelayer.h>
#include <layercheckbox.h>
#include "geologic-core/objects/geo/untemporal/Grid.h"
#include <geologic-core/algorithms/clustering/dbscan/DBscan.h>
#include <geologic-core/algorithms/clustering/kmeans/Kmeans.h>
#include "clustering/propagclustering.h"
#include "Common/color.h"
#include <clustering/testclustering.h>

class Vanet;

class ClusterManagerLayer : public SingleLayer {

public:
//*/ -------------------------------------------------
ClusterManagerLayer(Vanet* parent);
virtual ~ClusterManagerLayer();

//*/ -------------------------------------------------
virtual void draw();
virtual void draw(unsigned long long t);
virtual void drawCheckbox(QWidget *tab, QVBoxLayout *layout);

//*/ -------------------------------------------------
Vanet* parent;
std::unique_ptr<Grid> clusterGrid;

//std::unordered_map<std::string, GeologicCluster*>
currentClusters;
//DBscan algoClustering;
//PropagClustering algoClustering;
```

```
testClustering algoClustering;

std::unordered_map<std::string, Color> colors; // A color for each
Cluster

time_t currentT;

};

#endif // CLUSTERMANAGER_H
```