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Coverage Measurement of Data Dissemination in VANATEs

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Abstract

Vehicular ad hoc network (VANET) is an example of mobile applications developed recently of Intelligent Transportation Systems (ITS). This network comprises mainly of vehicles and road infrastructure, connected each to other for exchanging traffic data (V2V communication and V2I communication). It allows sharing data between vehicles in a collaborative way. In this thesis, we are particularly interested in road safety applications, designed for the exchange of information on road traffic. This kind of applications have strict Quality of Service (QoS) requirements, as data must be delivered thoroughly and without any delays. In this context, data routing will face several issues caused by rapidly dynamic topology, which characterizes VANETs, intermittent connectivity, and high mobility of vehicle nodes. Indeed, the problem of data dissemination in this field is non-trivial, and several research challenges must be solved in order to provide an efficient support for road safety applications. Specifically**,** we will address the problem of studying data dissemination's protocols and mechanisms in the new situation caused by the emergency of advanced comfort and driving assistance technologies in VANETs.

Key Words: Warning Information, Dissemination, VANETs, Simulation, Modeling.

Résumé

Le Réseau véhiculaire ad hoc (VANET) est un exemple de réseau mobile ad hoc (MANET), C'est l'une des applications qui a récemment développée des systèmes de transport intelligents (STI). Ce réseau est composé principalement des véhicules et des infrastructures routières qui sont reliées les unes autres de façon à assurer l'échanger des données de trafic (communication V2V et de la communication V2I). Il permet entre autres le partage collaboratif de données entre les véhicules. On s'intéresse dans ce travail par les applications de sécurité routière conçues aux échanges d'informations sur la circulation routière. Ce genre d'applications présente de stricte qualité de service (QoS), car les données doivent parvenir en temps réel et sans aucun retard. Dans ce contexte, le routage de données devrait répondre à toutes les préoccupations relevant d'une topologie dynamiquement rapide caractérisant les VANETs à savoir une connectivité intermittente, et une grande mobilité des nœuds de véhicules. En effet, le problème de la diffusion des données dans ce domaine est non trivial, et plusieurs défis sont à surmonter afin de protéger les applications de sécurité routière. Le présent travail est une contribution non-exhaustive qui proposerait des protocoles et des mécanismes de diffusion des données dans la perspective d'escorter l'exigence du confort de pointe et la conduite des technologies d'assistance dans VANETs.

Mots clés : Information d'avertissement, dissémination, VANETs, Simulation, Modélisation.

Chapter I Introduction

I-1-General Introduction

According to the World Health organization, road accidents have caused 1.25 million deaths and between 20-50 million worldwide injuries, for the single year 2013. This scary situation will get worse up to 65% more over the next twenty years if nothing is done to improve prevention and enhance safety road [1].

With the increasing number of vehicles, it becomes imperative to look for managing traffic and safety. Thanks to technological advances, it is possible nowadays to equip vehicles with a GPS device and form a dynamic network card called vehicular ad hoc networks (VANET). These networks are mainly composed of intelligent vehicles that communicate with each other and / or with roadside units (RSUs). VANETs are one of the recent developed applications in the intelligent transportation systems.

As the Mobile ad hoc networks (MANETs), vehicular ad hoc networks use wireless communications; their characteristics still remain complex than "MANETs" ones. Indeed, the high mobility of vehicles, the scope of covered areas and their density are the main reasons why network topology is highly dynamic. Consequently, this would affect the connections quality between vehicles. The primary objective of ITSs services is reducing the number of road accidents, improving traffic and optimizing of safety and traffic management. These applications require a certain service quality of data sharing between users. However, the nature of such networks complicates the data dissemination process.

Data dissemination is the fundamental operation in vehicular ad hoc networks, most of the existing works take advantage of the inter-vehicle communication to ensure information's dissemination.

This work proposes a combination between two subdomains: vehicular ad hoc network and simulation. The first one was mentioned above. The second sub area offers analysis and technical design of the most effective complex systems. It is the Simulation and Modelling field which offers a digital prototype of a model to predict its performance in the real world, and helps engineers understand under what conditions and in which ways a part could fail and what are the best requirements for the simulation model.

I.2- Subject Description

One of the services supported by Vehicular ad hoc networks (VANETs) is the integration of security applications. The potential gain linked to such applications is the reduction of road accidents since such communication can extend the perception of drivers. The extension of this perception is based on an exchange of messages carrying information on risky situations.

The vehicular ad hoc networks support two communication patterns; the communication between vehicle and infrastructure (Vehicle-to-Infrastructure (V2I)), and the communication in a collaborative architecture between vehicles (Vehicle-to-Vehicle (V2V)). The V2I communication architecture requires the integration of a communication infrastructure in roads. It can be relatively expensive in terms of cost and management. The V2V ad hoc network architecture type is quite simple to produce, but needs to refine the rules of channel access shared by vehicles for a reliable large-scale deployment.

Temporal synchronization mechanisms have been proposed and new techniques for the equitable sharing of network resources have been investigated. However, many problems persist particularly with respect to ensure reliable reception between vehicles beyond a certain range. It is obvious that one of the issues relating to VANETs concerned vehicles operating at high speed and that join the network unpredictably and transiently.

In this manuscript, we have paid attention to mechanisms and protocols, which are used to disseminate the information in VANETS, which requires a high rate of delivery, low loss rate and reliability for transmitting messages. To satisfy these requirements, we have adopted the following question strategy:

- What are the existed data dissemination technics?
- What are the available simulation and modeling tools?
- How to evaluate these mechanisms in order to choose the best one?

I-3- Objectives and Plan

Our objective in this study is to measure the coverage mechanisms of data dissemination using Simulation and Modeling technics. Two sectors have to be distinguished: Simulation and Networks in particular VANETs. Concerning our aim, we identify the following steps:

- An analyse of data dissemination technics. This step responds to two objectives: First, it precisely covers the field of our studies. The second objective is to provide the specific elements of analysis in our study. Hence, a state of the art about the previous work on simulation in VANETs will bear our choices.
- Master the simulation methods. In order to overpower Simulation and Modeling methods and tools in VANETs and to apply them in data dissemination mechanism, this step will focus on simulation technics in VANETs.
- Simulation study. Based on the previous two stages and taking into account the context specified to the studied area VANETs. In this step we propose a simulation model about coverage measurement of data dissemination in vehicular ad hoc networks.
- Implementation and experimental study. In this stage, we build a simulation model based on the previous steps in order to realise an experimental series on the proposed model aiming to validate it and measure and evaluate data dissemination mechanism in VANETs.

I-4- Structure

This manuscript consists of four chapters, organized in a logical progression of our contributions to improve data dissemination in Vehicular Ad hoc Networks.

The 2nd chapter describes vehicular ad hoc networks and their characteristics. We detail their applications and limitations. Then, we offer a state of the art of data dissemination in VANETs,

The 3rd and 4th chapters are devoted respectively to protocols evaluation and comparative study.

Chapter II

General View & state of the art

II-1-Introduction

Nowadays, vehicles are considered more than a simple means of transportation due to the huge recent technological advances and the new features associated with them, which endow them with a source of intelligence to interact with the road environment.

This chapter aims to give an overview of VANETs and delineate the context of this thesis. We present initially their characteristics and the types of applications they can offer. We will discuss later parts of their communication standard that interest us and will detail multiple existing techniques of data dissemination. We conclude this chapter with the challenges for effective data dissemination in VANETs.

II-2- Vehicular Ad Hoc Networks

VANETs are considered as a special case of mobile ad Hoc networks (MANET) [1]. They are from a set of communicating entities, compound vehicles and roadside units (RSU). Thanks to the different applications that support the VANETs, these networks are the cheapest way to avoid traffic jams and minimize fuel consumption. The technology used to connect a vehicular ad hoc network must comply with its characteristics and should offer a good compromise between performance, cost and penetration of technology. Technologies used are:

- Communication Systems: GSM / GPRS, UMTS.
- Digital radio broadcasting systems: RDS / TMC, DAB / DMB, DVBT / DVB-H.
- Computer Networks: WiMAX, Wi-Fi, DSRC.

Most of these technologies require the deployment of base stations to enable communication with and between vehicles. These stations are used in telecommunications systems to control access to the support and manage the roaming process, as well as in radio systems to disseminate information to connected vehicles.

Throughout our study, we base on a vehicular network that does not rely on an infrastructure. This assumption limits the operable technologies for our network to those of WIFI and DSRC [2], because only these two technologies today support the ad hoc mode without infrastructure. The use of direct communication between vehicles (V2V), reduces delivery times compared to a centralized system, especially when communications are local and short, as is often the case in VANET. This mode of communication, V2V, also can cover more areas which are concerned by the information because they are no longer limited by a base station networks features.

The scientific community has chosen to use the Dedicated Short Range Communication (DSRC) VANETs as the underlying technology, including radio frequencies reserved specifically for these networks, which reduces interference with respect to the use of WIFI. This technology supports the V2V modes as well as V2I modes. DSRC also offers adequate rate and communication range for VANETs applications.

II-3- VANETs Characteristics

VANETs have a number of specific characteristics that differentiate them from other types of networks without infrastructure. The main characteristics of VANETs which must be taken into account by any dedicated solution are:

- **Highly dynamic topology**: the movement of vehicles is characterized by speeds and directions may vary according to the scenarios. Furthermore, driver behaviour influenced by the information received from network can also cause changes in the network topology [3]. This generates:

1. A variable network density: the density of a VANET changes depending on the density of traffic, ranging from very high densities during bottling for example, at very low densities, such as roads very little popular [4].

2. Frequent disconnections: Due to the highly dynamic topology nature of VANET, connectivity changes frequently especially when the network density is very low, which increases the disconnections risk [5].

- **Strong time constraints**: Some VANTEs applications have very strong time constraints. They indeed require that the information exchanged reach the network participants in a timely manner so that their time reaction is optimal.

- **Large-scale network**: when deploying in urban areas, city centres or highways, which are very dense, wide network can be very important and a scaling of all their protocols is required [6].

- **Predictive Mobility**: unlike other mobile networks, the movement of vehicles is restricted by the topology, traffic signs, and by the movement of other vehicles. From these facts, mobility vehicles can be provided to some extent.

- **Lack of energy constraints and power calculation**: given that nodes composing a VANET are relatively large and produce for themselves energy during movement. These can be equipped with sensors, energy resources in sufficient numbers and capabilities.

- **Communications based on geographic location**: in addition to the common types communications between VANETs and other mobile networks such as unicast, multicast and broadcast, VANETs also support based communications routing data to a group of vehicles via designated geographical location. This is possible because the vehicles are equipped with most often quite effective location systems.

- **Radio canal characteristics:** in traditional wireless networks, data exchanges generally take place in open spaces without obstacles indoors or in enclosed spaces. Communications in vehicular networks are in an unfavourable external environment for the establishment of radio links due to the multitude of obstacles (forests, mountains, buildings ...) particularly in urban areas. These barriers cause a severe deterioration in the quality and signal strength issued.

These characteristics derive several challenges that can be summarized as follow:

- **Quality of service:** the demand for quality service depends on the supported applications. The main constraint in the security applications is latency. The validity of the information is limited in time; messages need to reach their destination in a short time to be considered relevant.
- **Reliable radio channel:** the role of radio channel management mechanisms is to offer reliable and robust transmission and a fair sharing of the communication medium. To achieve this objective in the case of vehicular networks, it is necessary to define methods to deal with two major problems of transmissions: inter-symbol interference due to the wave propagation and multipath effect Doppler caused by the movement of vehicles.
- **Routing:** Routing protocols are used in ad hoc communications. They can determine the result of nodes that packets must traverse to an exchange of information between remote entities. The problems to be met by routing protocols are the intermittent connectivity which makes them obsolete the already established routes and network partitioning that prevents the spread of packets.
- **geographical address and geocast:** routing geocast is a mechanism similar to multicasting in which the recipients are identified by geographical constraints. It is used by applications displaying data that are useful only for vehicles which are in a specific geographic area.
- **Security**: The security requirements must be taken into account both in the architectural design of the network and in the design of communication protocols. They differ depending on applications and include mainly the confidentiality, the authentication, consistency and data integrity and availability. Meeting these requirements in such dynamic and mobile systems like vehicular networks is difficult but particularly important as human lives are concerned.
- **Normalization vis-à-vis the flexibility**: it is obviously necessary to standardize communications to allow vehicles designed by different manufacturers to collaborate. However, because of trade issues, it is likely that manufacturers will want to create some differentiation standards.

II-4- Applications of VANETs

VANETs offer several types of applications such as infotainment applications [4], traffic management and road safety. Each level requires a different performance and service quality.

We generally consider three types of metrics, the delivery time from start to finish, in order to respect the life of information; the reception rate, to ensure a minimum rate of delivery of the data and finally flow to ensure a rate of access to the channel.

II-4-1- Information and Entertainment Applications

Information and entertainment applications, named as infotainment applications, aim to improve the comfort of drivers and passengers. They provide them, firstly, with general useful information, such as weather information, other on the location or the price of a petrol station, restaurant or hotel; and secondly, they allow passengers to access internet-based services such as online games or instant messages [7,8, 9, 3, 10, 6].

II-4-2- Traffic Management Applications

The messages exchanged in the traffic management applications aim to improve road traffic by optimizing it through the selection of the appropriate paths and roads, taking into account potential traffic jams or obstacles to pass by. This spreads the traffic, reduces the travel drivers time and saves on fuel consumption. An example of road traffic management application is illustrated in Figure II.01.

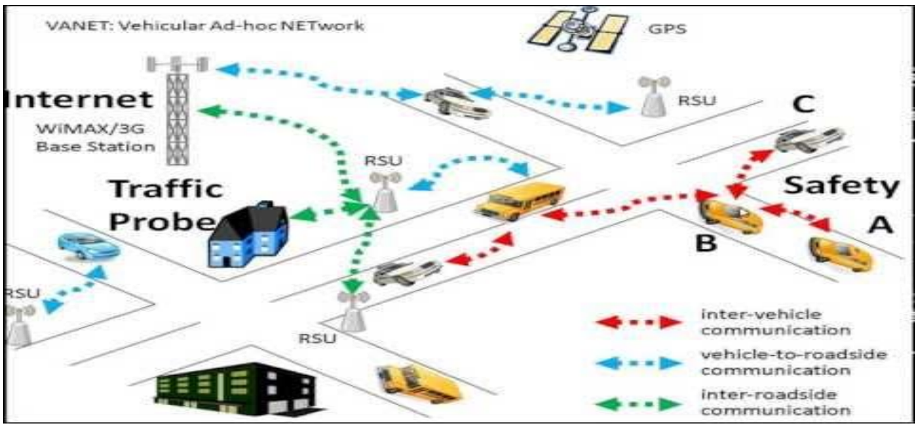

Figure II.01: Traffic management application [79]

Even if a vehicle equipped with a GPS and having a card is capable, by itself, to calculate the best route to follow, the performance of these applications are best when their updates in real time, or when a vehicle receives information news about road traffic from a roadside unit or from other nearby vehicles [11].

II-4-3- Safety Applications

Applications of road safety are the most important ones in VANETs. They aim to reduce the risk of road accidents [12,13,14], providing drivers with relevant and timely information.

To do this, data is collected through the sensors of vehicles to be processed and disseminated in the form of safety messages, for other vehicles and potentially available infrastructure, depending on the type of the applications [15,16]. There are various types of applications to include many aspects of the road safety, such as collision avoidance and remote diagnosis for vehicles maintenance [17]. Although the results of this thesis can be applied to various types of applications, the road safety application has motivated many choices therein.

Therefore, we provide examples of these applications in order to glimpse the specifics:

- **Collisions and risk's warning in intersections:** in this type of services, vehicles and infrastructure detect possible collisions between several vehicles cannot communicate with each other directly. Firstly, the service retrieves information concerning vehicles from different directions approaching an intersection, this through sensors present in the infrastructure. This information is analysed and treated and then probability of an accident or dangerous situation is calculated, a warning message is then disseminated among the vehicles at close of the intersection to prevent the danger.

- **Warning of an emergency vehicle:** the objective of this application is to provide a clear path for emergency vehicles and thus their free passage. In this service, alert messages are disseminated through unidirectional communications between vehicles, traveling on the same path with the emergency vehicle. The messages contain information related to the speed of the emergency vehicle, its management, the track on which it runs and the way followed. An example is shown in Figure II.02.

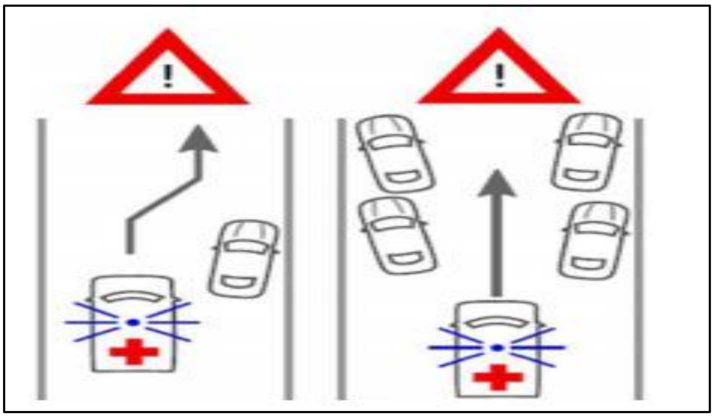

Figure II.02: Emergency vehicle [80]

- **Incidents Warning:** this application is designed to prevent potential incidents due to a dangerous situation. For example, if there is a fog on the way, a disabled vehicle, following mechanical problems or accidents, sends warnings to approaching vehicles circulating in the same direction or in opposite directions, using V2V communications and V2I, to inform them of his situation and location. An example of this application is illustrated in Figure II.03.

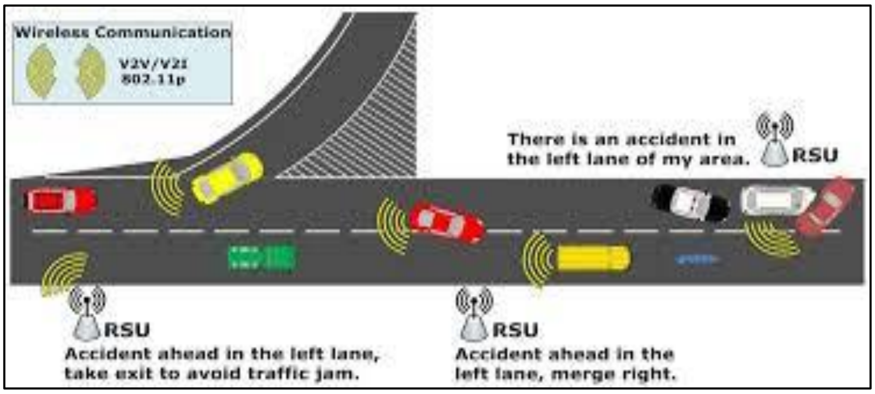

Figure II.03: Road safety application [81]

- **Highways collaborative automation**: This service monitors the position and the speed of vehicles via V2V and V2I communications to the circulate in groups on a highway. The service collects information about vehicles and fused with map data, in order to control vehicle movements and improve circulation.

There are two types of messages that can be spread by safety applications and road safety [18]. Periodic messages, they contain important information, which aim to help vehicles to decide about necessary actions to prevent the occurrence of dangerous situations on the road. These messages need to be released frequently, which can cause a waste of bandwidth allocated to wireless communications.

The second type is that of event-messages, they are priority messages, sent only when detecting dangerous conditions. These messages contain the location of the sender, the type of event and a timestamp. They must be delivered quickly, less than 100 ms, to other vehicles to make a profit from their content [17]. As previously stated, in this thesis we are interested in security applications and collaborative road safety because they have strong constraints in terms of delivery time of messages and quality of service.

II-5-Standards

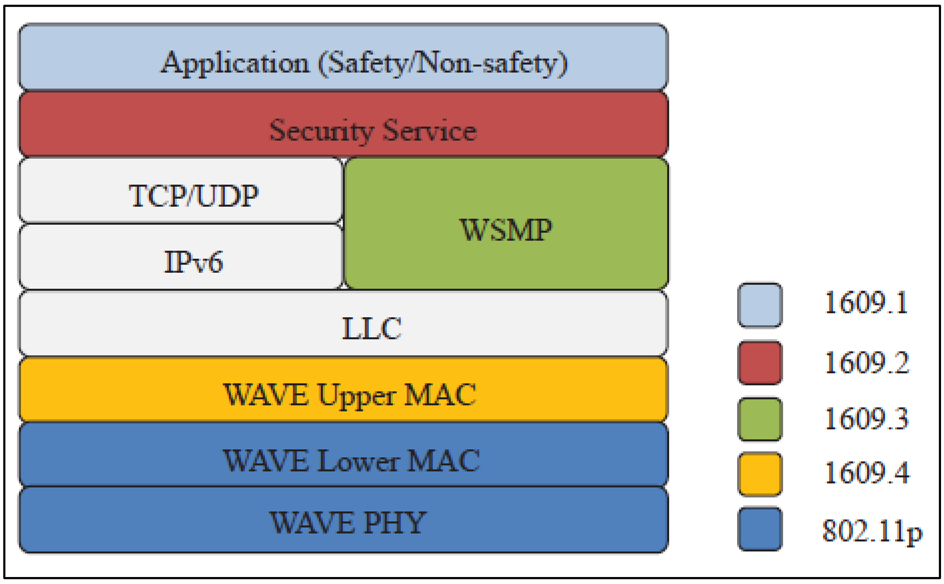

Figure II.04: Wave protocol stack. [82]

The DSRC [2] standard was designed specifically for communications in VANETs. For this purpose, radio frequencies were specifically dedicated by the Federal Communications Commission (FCC) in the USA. As a family of IEEE 1609 protocol was proposed in the protocol stack Wireless Access in Vehicular Environments (WAVE), managing the wireless access in vehicular networks. WAVE, shown in Figure II.04, consists of:

- **IEEE 802.11p**: Which describes the physical and MAC layers,

- **IEEE 1609. 1:** That describes the resource management service and defines the format of the messages at the application level.

- IEEE 1609.2: Which describes the security services, such as packet format and functions of encryption and authentication.

- **IEEE 1609.3:** Which describes the functions of the network and transport layers as addressing and routing. It also includes the Wave Short Messages Protocol (WSMP) for inter-vehicle communications, which is an alternative to IPv6.

- **IEEE 1609.4:** introduces multi-channel access mode to the physical layer IEEE 802.11p. The IEEE 802.11-2012 [20], formerly known as IEEE 802.11p [21] introduced new characteristics to the physical layer and the MAC sublayer to improve communication in VANETs.

The IEEE 802.11p uses the DSRC [2] communication channel, Dedicated Short Range Communication, which is specially designed for medium-range applications and sensitive period, to adapt to the mobility of vehicles and offer a low error rate, namely 10- 6 at a speed of 160 km/h. The proposed rate varies from 3 Mbit/s to 27Mbit/s with a theoretical transmission range of up to 1000 meters.

II-5-1- Physical Layer

The allocation of the channels is standardized by ETSI [22] and the organization CEPT in Europe [19]. A bandwidth frequency equal to 30 MHz is allocated on the 5.875 GHz spectrum 5905 [23], using the OFDM transmission technique on DSRC. DSRC specifications FCC offer seven different channels 10MHZ each as shown in Figure 05.

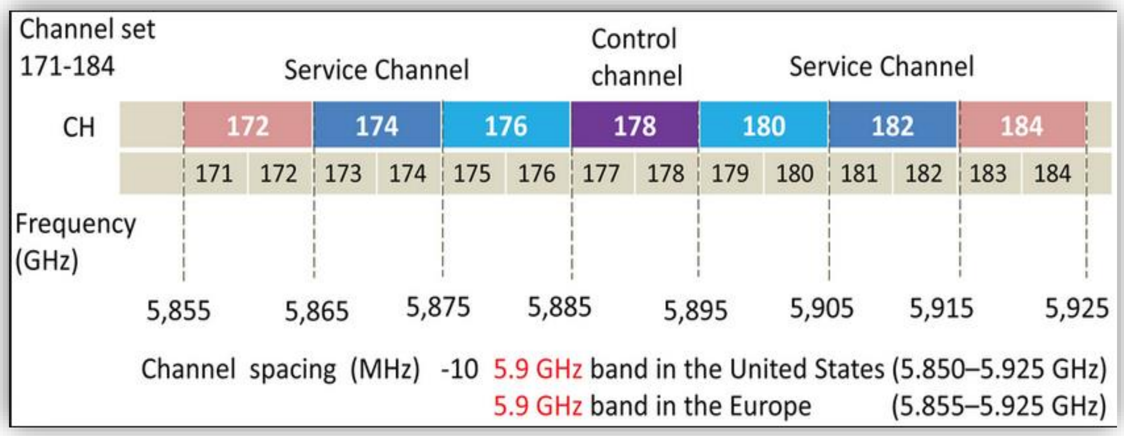

Figure II.05: Wave channels. [83]

These seven channels include a control channel (CCH) and six service channels (SCH). In the US standard, the role of the control channel is limited to the transmission of network management messages such as switching between channels and services announcements. Service channels each have a different role, channels 172 and 184 are dedicated to public safety applications. While in the European standard, the control channel is mainly dedicated to road safety messages and six service channels are dedicated to applications remains. Throughout our work, we consider the CCH be reserved mainly for road safety applications.

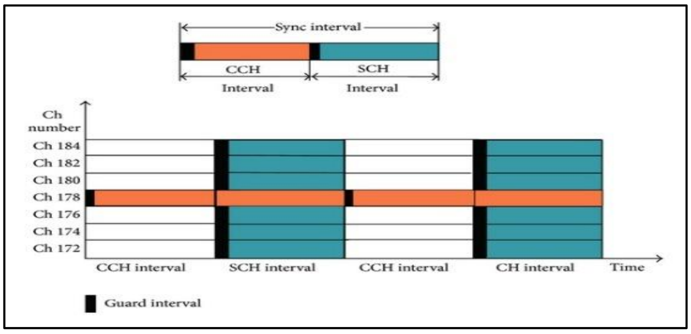

Figure II.06: Multi-channel mechanism. [84]

At the upper MAC sub-layer of the WAVE protocol stack, a multi-channel mechanism is proposed, as shown in Figure II.06. It divides a synchronization interval, with a duration of 100 ms, into two equal time 50 ms. The first of them is for sending safety messages on the CCH channel in order to maximize the receipt of these priority messages, as well as the transmission of network management messages, to schedule failover between channels, for example.

During the second interval, the vehicles are free to choose their listening channel. To allow the change of listening channel, a 4 ms guard interval is triggered, the channel than is considered busy, and no vehicle will transmit little message.

II-5-2- MAC Layer

With EDCA, high-priority traffic has a higher chance of being sent than low-priority traffic: a station with high priority traffic waits a little less before it sends its packet, on average, than a station with low priority traffic. This is accomplished through the TCMA protocol, which is a variation of CSMA/CA using a shorter arbitration inter-frame space (AIFS) for higher priority packets. The exact values depend on the physical layer that is used to transmit the data.

In addition, EDCA provides contention-free access to the channel for a period called a Transmit Opportunity (TXOP). A TXOP is a bounded time interval during which a station can send as many frames as possible (as long as the duration of the transmissions does not extend beyond the maximum duration of the TXOP). If a frame is too large to be transmitted in a single TXOP, it should be fragmented into smaller frames. The use of TXOPs reduces the problem of low rate stations gaining an inordinate amount of channel time in the legacy 802.11 DCF MAC. A TXOP time interval of 0 means it is limited to a single MAC service data unit (MSDU) or MAC management protocol data unit (MMPDU).

The levels of priority in EDCA are called access categories (ACs), "Voice", "Video", "Best Effort" for standard applications and "Background" for the remaining applications the contention window (CW) can be set according to the traffic expected in each access category, with a wider window needed for categories with heavier traffic. The CWmin and CWmax values are calculated from aCWmin and aCWmax values, respectively, that are defined for each physical layer supported by 802.11e. [85]

Table II.01: Default EDCA Parameters for each AC. [85]

AC	CWmin	CWmax	AIFSN	Max TXOP
Background (AC_BK)	15	1023	7	0
Best Effort (AC_BE)	15	1023	3	0
Video (AC_VI)	7	15	2	3.008ms
Voice (AC_VO)	3	7	2	1.504ms
Legacy DCF	15	1023	2	0

II-6- Dissemination Technics

An effective solution in data dissemination should absolutely take into consideration VANETs characteristics as: the network size, vehicle speeds, intermittent network connection that causes its partitioning in many islands and the different needs of applications in terms of service quality. Theoretically, several strategies have been proposed. Each of them may require more than one hop to route its data, and the deployment of infrastructure or not, such as roadside units (RSUs).

II-6-1- Dissemination Strategies

II-6-1-1- Broadcast

One of the most used approaches for data dissemination in VANETs is that using diffusion. It can be used in a single jump as several jumps. A message sent by a transmitter vehicle broadcast is transmitted to all its direct neighbours and is still broadcast once by each of its receivers, until the recipient (s). This approach requires no prior information on the neighbours of the vehicle, allowing it to ignore the lack or inaccuracy of the information on the network topology. It increases the rate of delivery and improves transport speed data as a vehicle recipient receives multiple copies of the message, coming through several routes. However, this approach also increases the competition for access to the communication channel and the use of bandwidth, which does not allow the scaling risk to generate strong network congestion [26].

The authors of the study [27] propose a multihop broadcast protocol for urban environments, named UMB (Urban multi-hop broadcast protocol), which aims to remedy the problems associated with the massive distribution. To send a message, a sender sends the vehicle by diffusion its direct neighbours and only the farthest vehicle rebroadcasts. Meet an intersection, vehicles are selected as repeaters and are responsible for rebroadcast information on the various segments of the intersection.

The authors of the solution [28] using the same spread approach. A message is sent by broadcast to achieve a certain group of vehicles. However, from the second transmission of the message, only vehicles on the edges are selected as torchbearers.

The criteria for the selection of torchbearers in both approaches concern mainly their geographical positions. This is not sufficient to meet the VANETs issues such as adaptation to changing network density, because no relationship between the number of torchbearers and density is given.

II-6-1-2- Probabilistic

This approach tries to reduce redundant messages generated by calculating the dating probabilities between two vehicles before deciding the way of dissemination of information, without requiring knowledge of the network topology.

A vehicle using this approach can be based on knowledge of the network, its historic meetings with other vehicles, as well as the information it has collected on mobility and the locations of other network vehicles.

The solution [26] uses this probabilistic approach, decisions on choice of vehicles torchbearers for the retransmission of a message are based on dating probabilities vehicle (s) recipient (s). Whereas in solutions [29] and [30], the receivers of a message vehicles themselves calculate their probability of retransmission, based on the distance between the transmitter of the vehicle. Over this distance is greater more probability of retransmission is important. The authors of the solution [31] use the criterion of the distance between a receiver vehicle and a source vehicle to calculate the probability of retransmission and there add a parameter on the local network density, the number of direct neighbours of the receiver vehicle to reduce the number of torchbearers of vehicles where the density is strong.

II-6-1-3- Geographic

This dissemination approach is based on information from the localization of vehicles contained in the mess ages of control, periodically broadcast in the network, when it follows approach pro-active [32], or when broadcast on request, at a reactive [33] approach. Each vehicle regularly updates a table containing the history of the locations of its neighbours, in order to convey its messages by the shortest route and thus reduce delivery time. In fact, in a release, the nearest vehicle recipient (s) is selected during each jump. This approach also allows targeting a group of vehicles thanks to their geographical coordinates, as are applications for alerting collision risk driver's intersection.

II-6-1-4- Channel Oriented Resources

Because the resources of the communication channel are limited, access to the channel and the allocation of its resources become an optimization problem. However, this problem may be NP complete because of all the variants that need to be considered and the limited information on the network available to the vehicle. Then offer solutions based on heuristic algorithms, such as the study [34] that provides access data routing on the consideration of the history of the transmitting vehicle encounters with other networked vehicles. This in order to estimate the potential congestion and density of the network, then take them into consideration to improve the delivery rate and reduce the number of duplicate messages.

In the solution [35], each node maintains a table with information about the flow and channel conditions in order to choose which node torchbearer it is best to carry its message.

However, these solutions require the exchange of messages between vehicles to maintain control over the use of the channel resources.

Another solution [36], improves the emergency message reception rate by allocating a portion of the available bandwidth. In this solution, each node first sends a signal pulse form, then his emergency message.

II-6-1-5- Messages Oriented Priorities

To meet the different needs quality service multiple applications of VANETs, dissemination solutions offer an adaptation of the release with respect to the importance of the message exchanges. In order not to systematically remove all new incoming messages in case of network congestion.

The solution [37] solves this problem by setting priorities for access to the channel communication from the access points ACs fixed by EDCA [24], for each message.

Another solution [42], allocates tokens to queues formed by the messages wishing access to the channel. It manages access to the channel by weighting the number of tokens available from the density of the channel and the priority of the messages. Like the latter, the solution [38] order to send messages based on the available resources of the canal and the importance of the message, using a waiting queue system where greater priority is given to messages most urgent.

II-7- Data Dissemination Protocols

In Vehicular adhoc networks, there is very high mobility in which each vehicle node act as a router as well as host and sending packets to other mobile nodes and changing their topology very fast [69]. The topology keeps on changing and also vehicles are not always connected to the network. There are frequent disconnections in VANETs. Therefore, routing protocols used in MANETs are not necessarily suitable for VANETs. Routing can be defined as finding optimal path between source and destination node and then sending message on that path so that message can reach its destination easily, quickly and on time. The main problem that needs to be solved in VANETs is how to exchange information in scalable fashion [70]. The answer lies in Data Dissemination Protocols which differ from one another. The most famous data dissemination protocols are:

II-7-1- Urban Multi-hop Broadcast Protocol

This is multihop broadcasting based protocol that uses RTB/CTB handshake approach for sending packets and receiving acknowledgments. Message dissemination is very difficult in urban areas that crowded with tall buildings and number of intersections [71].

This protocol is designed to address broadcast storm, hidden node and reliability problems in multihop broadcast. The UMB protocol is composed of two phases namely directional broadcast and intersection broadcast.

i. **Directional Broadcast**: In this method, sender node tries to choose the single node (furthest one) in the broadcast direction to assign the duty of forwarding and acknowledging the packets.
ii. **Intersection Broadcast:** The major problem of disseminating data lies in urban areas that are crowded with tall buildings and intersection points and these tall buildings can block communication among vehicles whether they are in transmission range of each other because of line of sight of problem. UMB protocol addresses this problem by installing repeaters at intersections because at intersection points line- of- sight problem is not so effective and repeaters have the best line of sight to the other road segments.

II-7-2- Ad-Hoc Multi-hop Broadcast Protocol

Ad-hoc Multihop Broadcast (AMB) protocol is an adhoc extension of UMB protocol which handles broadcasts at intersections with the use of repeaters while AMB protocol does not use repeaters at intersections thus eliminating major limitation – infrastructure dependence – of the UMB protocol by employing an efficient intersection broadcast mechanism.

In the AMB protocol, directional broadcast is same as that of UMB protocol but in case of Intersection broadcast- vehicles attempt to choose the closest vehicle to the intersection using a fully ad-hoc algorithm and the chosen vehicle forwards the packet to all road segments except the one that the packet is received from [72].

The AMB protocol is composed of two phases:

i. **Selecting the HUNTER vehicle**: The Hunter vehicle tries to select the closest vehicle to the intersection. For this purpose, intersection region will be defined and the first vehicle chosen in the intersection region becomes the Hunter vehicle [72].

ii. **Selecting a vehicle for branching the packet propagation**: The Hunter vehicle initiates the search to find the closest vehicle to the intersection and in response to this search, vehicles reply with a black-burst according to their distance from the intersection i.e. vehicle closest to the intersection sends the longest black-burst and this new RTB packet is known as Intersection RTB (I-RTB) that is different from the regular RTB employed in directional broadcast in which furthest vehicle from source node sends the longest black-burst. And finally vehicle closest to the intersection becomes responsible for propagating the message to other road segments [72].

II-7-3- Acknowledgment-Based Broadcast from Static to highly Mobile Protocol

This is broadcast based protocol that is suitable for wide range of vehicular scenarios, which only contains local information acquired by periodic beacon messages. From this information each node can independently decide whether to forward received packet or not. In this protocol, a vehicle that receives a data packet will not forward that packet immediately rather vehicle will check if retransmissions from other neighbours already cover its whole neighbourhood in order to avoid redundancy. And this is done by computing Connecting Dominating Set (CDS) of each vehicle. Nodes in the CDS will select a shorter waiting time-out than regular nodes. This allows them to retransmit first if their neighbourhood has not been covered before. That is, there are two different techniques, CDS and neighbour elimination scheme (NES).

Beacons also contain identifiers of the recently received broadcast messages, which serve as acknowledgments of reception. In this way, nodes can check whether all their neighbours successfully received a message. If this is not the case, a retransmission is scheduled. Otherwise, retransmission would be redundant.

In both cases, when a new neighbour emanates, nodes restart their evaluation time-out if the message being disseminated is not acknowledged. If the message identifier is actually included within the beacon, the neighbour already got the message and no retransmission is scheduled. Hence, the use of acknowledgments makes the protocol more robust to transmission failures while, at the same time, saves redundant retransmissions [73].

II-7-4- Abiding Geocast

It is a system geocast of communication inter vehicle for the dissemination of warning information in VANET. This model is proposed in order to ensure to: increase the probability of access to all relevant vehicle and reduce the overhead. This system uses different notions of time and space. To ensure that the warning information had reached the group of vehicles exist in a geographical area. Of which, the first vehicle detects the risk starts broadcasting a warning to other vehicles to inform them of this dangerous situation. In this work the authors used different dissemination strategies: (1) To achieve the first goal, they used the vehicle as reverse relay (2) Second goal: to update a time Waiting dynamically active vehicle for the next release.

II-7-5- Adaptive Delay-based Geocast Protocol in Urban VANET

Broadcast- based geocasting enables efficient data dissemination to vehicles within the given geographical area. Before this protocol, no one has taken into account the urban areas for suppression mechanism. After looking at deep inside it came out that most of existing broadcast suppression methods do not work in urban areas because in urban areas there are several number of intersections and buildings available and buildings can block direct communication of vehicles whether they are in transmission range of each other [74] as shown in Figure II.7(a).

Now this protocol named Urban Geocast based on Adaptive Delay (UGAD) says that as building are acting as obstacles for data dissemination so there is need to transfer data to those vehicles that can be seen directly; no building or no any other obstacle is there. And more number of vehicles that can be seen directly by source vehicle when source vehicle reaches at intersections. Therefore, according to this protocol opportunity for sending data at intersections should not be missed [74] as shown in Figure II.7(b).

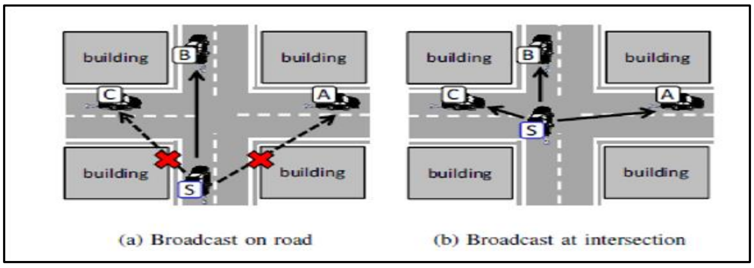

Figure II.07 :Broadcast in urban environment. [74]

Table II.02 Comparison of the existing protocols

Existing Protocol Name	Mechanism used	Pros	Cons	Simulation platform used	Metrics used for evaluation
UMB	Broadcast	Saves bandwidth and reduce redundancy by choosing one vehicle for forwarding the packet	Cost incurred on installing repeaters that are used to forward packets at intersections	MATLAB CSIM	Load Generated Per Broadcast Packet, Packet Delivery Ratio, Dissemination Speed [75]
AMB	Broadcast	saves cost as repeaters are not used at intersections	wastage of time in finding the vehicle closest to intersection	NS-2	Message Delivery Ratio, Packet Reception Rate [76]
ABSM	Broadcast	It resolves propagation at intersection without recognising intersections	Protocol overhead is high when there are multiple simultaneous broadcasting tasks	NS-2	Reliability, Number of Message [73] Transmissions per Involved Vehicle, Control Overhead per Vehicle, Delivery Latency
AG	Geocast	Dissemination only into relevant area	Fragmentation caused by vehicles out of range of transmission	OMNeT++	Broadcast Overhead Message delivery
UGAD	Geocast	Reduce redundant rebroadcast and increases packet arrival ratio	no method to ensure that message has been reached to destination or not	NS-2	End to End delay, Packet Delivery Ratio [74]

II-9- Dissemination Problems

VANETs have the advantage of not being conditioned by the related issue in memory space, computing capacity and energy. However, they suffer from the massive amount of data to send and extent of the geographical areas to cover. These combined with the dispersion and the high mobility of vehicles, lack or inadequacy of infrastructure, and the variable density of the network, create several problems in data dissemination. Below we list a few:

- **Issues related to the variable density and sporadic connections:** the density of vehicles in a VANET is highly variable, it can be very low, as in the case of a country road with low traffic or very strong in a heavily congested urban network. This has an impact on the rate of delivery and time to route data. Indeed [16, 39].
- **Channel Resource Sharing**: VANETs lack coordinator for allocating bandwidth to vehicles. It then becomes the responsibility of each vehicle to manage, fairly, those resources [45].
- **Encouraging cooperation:** the dissemination of data in VANETs is done, usually, in a collaborative way to address the non-constant presence of infrastructure and support the mobility of vehicles. For this it is essential that vehicles are willing to cooperate and communicate messages to their neighbours. We provide the incentive to cooperation in a VANET our trust model, which is also an incentive model.

II-10-Conclusion

VANETs have the ability to support a multitude of applications, ranging from Simple comfort applications to other more important as those for safety and road safety. These applications require effective strategies for managing communication channel resources, quality of service and security of communications, among others.

However, even if we can consider VANETs as a subset or a specific case of MANET, existing solutions for those do not apply as such to VANETs, because of their particular characteristics. So there are many research questions in the field of VANETs. In this thesis, we will focus on those related to the dissemination of data.

Chapter III Simulation & VANETs

III-1-Introduction

The main purpose of VANETs research is to develop communication systems between vehicles for the dissemination of data and an efficient way to provide safety and comfort its users. Many network vehicular scenarios require a wide variety of communications protocols.

In order to evaluate protocol implementations in a real world, the use of simulation tools become a very important as one of the testing and evaluating basic steps to develop and implement networking protocols of VANETs.

VANETs simulation is fundamentally different from the simulation of mobile ad hoc networks (MANETs) due to its particular characteristics such as restricted topologies, signal fading, high mobility, nodes with different speeds and different behaviours of drivers.

For this reasons various simulation tools have been developed, including network simulators, mobility generators and hybrid simulators. Figure III.08 shows a description of popular VANET simulation tools. Nowadays these tools are still being used and improved. The aim of this chapter is to present simulation technologies for VANETs which will help as to master simulation methods and tools.

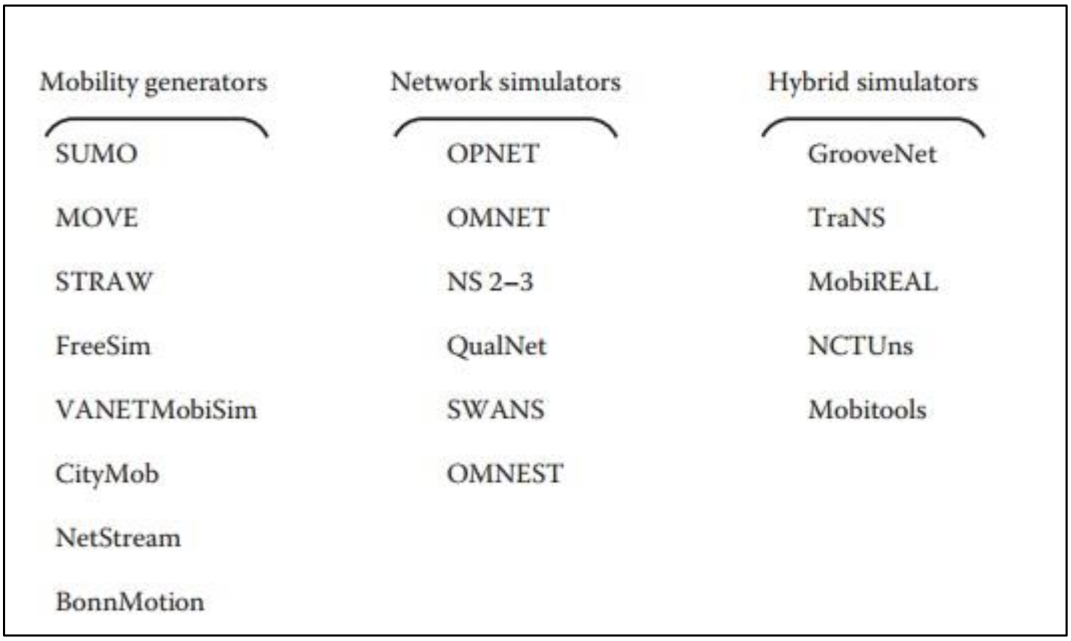

Figure III.08: Popular simulation tools for VANETs [40].

III-2- Network Simulator

A network simulator must implement widely accepted communication standards, such as the different IEEE 802.11 specifications. Specific both the physical layer and the MAC layer of the ISO OSI reference model.

A network simulator is a software tool that predicts the behaviour of a network. The main aim of network simulation is to monitor the behaviour of the network which is calculated either by network entities using mathematical formulas or by capturing and playing back observations from a production network [41]. Attributes can also be modified in a controlled manner to assess how the network would behave under various conditions, typically with the support of most popular protocols and metric networks used at different layers since all layers permit the evaluation of parameters like data traffic transmission, packet level of source or destinations, reception, background load, routes, links, control channels, and packet delay variation (PDV), among many other metrics and parameters. This section will present some of the most promising network tools to simulate VANET scenarios together with their principal characteristics to analyse communication between vehicles and vehicles to infrastructure.

III-2-1-OMNeT++

OMNeT++ [42] is a network simulator based on discrete events and is modular, object oriented, and developed for different operating systems such as Linux, Mac OS/X, and Windows. Its main area of application is in the simulation of wire and wireless communication networks. OMNeT++ provides an architecture of modules programmed in C++ and alternative programming languages like Java and C#. Such modules are reusable because OMNeT++ supports the interaction with the user through a graphical interface, due to its modular architecture, and the simulation kernel can be embedded within different applications [43, 44].

OMNeT++ is gaining more and more popularity in the scientific community for the following capabilities:

• Modeling protocols
• Modeling wireless and wired communication networks
• Validation of hardware architecture

• Performance evaluation of software

• Modeling queuing networks

• Modeling multiprocessor and distributed systems

• Modeling discrete event systems where entities need to communicate through the exchange of messages or packages.

III-2-2- NS-2 and NS-3

NS-2 [45] and its successor NS-3 [46] are discrete event simulators. They are open source and licensed under GNU GPLv2. NS-2 is being partially maintained but not being considered for journal publications. It still has a big user base. NS-3 is still under constant development and offers some interesting characteristics for developers. NS-2 network simulations are composed of C++ code, which is used to model the behaviour of the simulation nodes, and oTcl scripts that control the simulation and specify further aspects, for instance, the network topology.

NS-3 [47] is one of the network simulators widely used in academic and research community. The NS-3 simulation core supports research on both IP and non-IP-based networks.

Font et al. [48] provide some meaningful remarks about current differences between these two tools from developer's point of view. Leaving performance and resources consumption aside, technical issues might help to choose one or another, depending on simulation and project management requirements.

III-2-3- QualNet

QualNet [49] is a commercial version of Global Mobile Information System Simulator (GloMoSim), and it is designed to be extensible. QualNet permits the use of different protocols in a variety of standard or user-configured network components and applications running on the network. The protocol stack for wireless networks is divided into a set of layers, each with its own API. The modular implementation allows consistent comparison of multiple protocols in each layer in the ISO OSI reference model.

QualNet can model thousands of nodes by taking advantage of the latest hardware and parallel computing techniques. It can permit to model large networks with high fidelity by running multicore, on cluster, and multiprocessor systems.

The most significant QualNet components are as follows [50]:

- QualNet analyser. A statistical graphing tool that displays hundreds of metrics collected during simulation of a network scenario.
- QualNet packet tracer. Provides a visual representation of packet trace files generated during the simulation of a network scenario.
- QualNet file editor. A text editing tool that displays the contents of the selected file.
- QualNet command line interface. Enables a user to run QualNet from a command window.
- QualNet external interfaces. It can interact with a number of external tools in real time.

III-2-4- Scalable Wireless Ad Hoc Network Simulator

Scalable Wireless Ad Hoc Network Simulator (SWANS) is a wireless network simulator built on Java in Simulation Time (JiST). SWANS is organized as an independent software component that can be complemented to sensor or wireless networks, and it has capabilities that are similar to Ns-2 and GloMoSim. SWANS [51] is also able to simulate larger network topologies by making efficient use of memory. The latest version nowadays available was released in 2007. There is no version for Windows environment. SWANS is a repository for the development of extensions for the JiST/SWANS wireless network simulation test bed. It currently includes a mobility model for VANET simulations and a visualization tool. SWANS is an open source that includes graphical user interface (GUI) and supports parallel processing but does not support IEEE 802.11p. In [52], the authors propose enhancements to AODV protocol by minimizing its control messages overhead. The simulation was done using JiST/SWANS simulator. Another interesting development made with SWANS [53] is a module called ASH (application-aware SWANS with highway mobility), which makes a significant contribution by allowing for the needed two-way communication between the mobility model and the network model because most VANET simulators do not allow for feedback between the vehicle mobility model and the network simulator. This adds to the scalable SWANS simulator allowing for realistic VANET simulations of important safety and traffic information applications.

III-3- Traffic/Network Simulator Integration

Analysing VANET is a costly and time-consuming job because the deployment of various VANET applications differs in their features, design, working, and testing. Research community around the world has developed and studied many protocols and applications with various simulation software tools to model different conditions. VANET simulators help to perform real-world activities under varying conditions while reducing high cost and time.

To integrate two components, that is, network and mobility simulators, it is necessary to simulate VANET. These two simulators provide independent [54] functionalities. On one hand, network simulators permit topology building; on the other hand, mobility simulators produce the traces that contain the file with the coordinates specifying the movements of vehicles, which can be loaded to the network simulator.

III-4- Mobility Models

One of the most significant components for VANET simulation is a mobility model that produces right decisions from simulation experiments and thus will carry through to real deployments; in other words, the mobility model is the pattern that describes the movements of mobile nodes during a simulation time within the simulated area. Some authors classify [55] mobility models into microscopic, macroscopic, and mesoscopic, which are described in the following.

III-4-1- Mesoscopic Flow Model

This model combines elements of microscopic and macroscopic traffic flow models. Mesoscopic model may take different forms such as the modeling of the headway distribution or the size or density of a cluster of vehicles and can describe the interactions between vehicles at an individual level. A specific model may describe the velocity distribution at a specific time and space or the vehicular arrival rate.

Mesoscopic flow also models the mobility at the flow level where a number of cars are characterized by certain averaging properties like average speed or time headway at a specific time and space and at the same time controls the behaviour of a vehicle as a function of this information, with the characteristic that the flows are distinguishable.

III-4-2- Microscopic Flow Model

The major characteristic of this VANET traffic flow is to model vehicular traffic avoiding accidents by controlling each individual vehicle to maintain a safe inter-distance between cars, a safe time headway, or both. Really microscopic models simulate traffic by following each vehicle from moment to moment or executing events in time sequence. In addition, microscopic models are in charge of modeling the location, velocity, and acceleration of each vehicle that participates in the simulated scenario, and they are doubtless the most popular class of driver models because microscopic flow models, generally, represent time, position, speed, and even acceleration as continuous functions, but most have been extended to run in discrete time.

III-4-3- Macroscopic Flow Model

The macroscopic flow model governs vehicular traffic, like the road topology, defining speed limits, constraining cars movement, characterization and number of lanes, overtaking and safety rules for each street, or the traffic sign description establishing the intersection crossing rules. In general terms, a macroscopic flow model simulates the behaviour of vehicular traffic flow such as traffic density, rather than that of each individual vehicle.

III-5- Mobility Simulator

The traffic modeling is an area of knowledge fairly investigated by the civil engineering for the correct modeling of vehicular traffic in the design phase and the construction phase of new roads and intersections. To increase the level of reality in the simulation of VANET, the use of vehicular mobility generators through traffic models is necessary. Among the most relevant options offered by traffic simulators are to allow varying the number of lanes and the shape of the roads, including traffic lights and intersections. In terms of vehicular mobility, they usually implement a car-following model, as well as a multilane changing model to simulate overtaking among vehicles. At the moment, several simulation software environments exist and they are capable of generating trace files reflecting vehicles' trajectory or movements.

Simulation environments currently exist, which are capable to generate trace files that reflect the movement of vehicles. These trace files must be exported to the network simulation programs. Some of the most important mobility simulators will be briefly described as follows.

III-5-1- Simulation of Urban Mobility

It is a microscopic and open-source traffic generator capable to handle vehicle environments up to 10,000 streets. Among its main features are handling movements, collision-free vehicle, and different types of cars. Each vehicle has its own path and is simulated individually. One of the major drawbacks is the fact that the generated traces cannot be directly utilized by any available network simulator; for this reason, the creation of an extension or script that converts data files generated by Simulation of Urban Mobility (SUMO) to be understood and interpreted by the corresponding network simulator is needed.

SUMO [56], developed and maintained by the Institute of Transportation Systems at the German Aerospace Center, runs on all major well-known operating systems, and its basic programming language is C++.

III-5-2- Mobility Model Generator for Vehicular Networks

Mobility model generator for vehicular networks (MOVE) can generate realistic mobility models for vehicular network simulation. MOVE works on SUMO. MOVE [57] basically consists of two components: map editor and editor of vehicle movement. The map editor is used for topology that routes can be created manually or automatically or by importing maps from a database like TIGER, OSM, or Google Earth. In turn, the vehicle editor is used to generate the movements of vehicles; the output of previous editors is a trace fie that contains the information of the moving vehicles used by the network simulator like NS-2 or QualNet [58].

III-5-3- Street Random Waypoint

Street random waypoint (STRAW) is a traffic modeler that basically consists of two kinds of implementations, route management and execution, one of which is a modified version of the model random waypoint that requires source and destination information. The model random waypoint determines a vehicle's path at each intersection, STRAW [59] uses information origin–destination and interarrival time to lead mobility in the network.

Further, the pair of information origin–destination is selected by each car, and the paths are initially calculated by a metric or minimum cost as fastest time or shortest distance, so the model can be configured to recalculate the route of the vehicle.

III-5-4- FreeSim

FreeSim [52] is licensed under the GNU (General Public License), and its code is freely available. FreeSim is a macroscopic or microscopic traffic simulator that can be customized. FreeSim allows multiple systems to be easily represented by highways and loaded into the simulator as a graphical data structure with a weight at the edges of the roads determined by the current speed of the mobile nodes. The traffic and graph algorithms can be created and executed by the entire network or vehicle individually, and the traffic data used by the simulator can be generated by the user or collected in real time or provided by any entity of transportation management. Nodes in FreeSim have the ability to communicate with the monitoring highway traffic system that makes it an ideal traffic modeler for the simulation of ITS.

III-5-5- VanetMobiSim

VanetMobiSim [60] is an extension of CanuMobiSim that corresponds to a framework for the modeling of vehicular mobility. It is based on Java and can generate traces of movement in different formats. Meanwhile, VanetMobiSim, as an extension, focuses on vehicular mobility at the macroscopic and microscopic levels in the context macroscopic level. VanetMobiSim has the ability to import maps from American Census Bureau TIGER and provides implementations of various random mobility models as well as models of physics and vehicle dynamics.

III-5-6- CityMob

CityMob attempts to resolve one of the most critical issues in simulation studies of VANET related to the mobility models in order to get reliable results. CityMob permits to create urban mobility scenarios, including the possibility of modeling vehicular accidents. The modeling was designed to integrate with the network simulator NS-2. In CityMob, three types of mobility models are implemented: (1) simple model, (2) Manhattan model, and (3) downtown model.

Specifically, downtown model shows that it is a fairly realistic model for the simulation of vehicular traffic accidents. It also shows that a moderate number of vehicles is required for flooding algorithm to be effective. Martinez et al. [61] show the performance of an analysis to obtain more detailed results by comparing the behaviour of the system with each mobility model.

III-5-7- NetStream

NetStream (network simulator for traffic efficiency and mobility) has been developed to simulate traffic over wide areas to predict the effects of ITS in order to reduce traffic congestion, reduce pollution, and eventually measure the traffic density. In order to calculate the flow of traffic in large areas with high-speed vehicular movement, NetStream [62] uses a density method block that computes the movement of the nodes by means of an approximation of the traffic flow and estimates the rate of guided vehicles. NetStream uses a traffic flow model that is able to calculate the movement of each vehicle, as required in ITS. Newest version of NetStream applies predicting traffic conditions in real time as guidelines in dynamic routing.

Overall, NetStream was developed to evaluate the efficiency of ITS, on one hand, and provide traffic information and related measures in traffic restrictions, on the other hand.

III-5-8- BonnMotion

Mobility Scenario Generation and Analysis Tool is a Java software that creates and analyses mobility scenarios and is most commonly used as a tool for the investigation of MANET characteristics. Scenarios can be exported to several network simulators, such as NS-2, NS-3, and GloMoSim/QualNet. BonnMotion [63] is being jointly developed by the Communication Systems group at the University of Bonn, Germany.

There are two possibilities to feed input parameters into the BonnMotion scenario generation. The first one is to enter the parameters on the command line, and the second one is to have a fie containing the parameters. These two methods can also be combined. In this case, the command line parameters override those given in the input fie. The scenario generator writes all parameters used to create a certain scenario to a file. In this way, settings are saved and particular scenario parameters can be varied without the need to re-enter all other parameters.

The most important mobility models for VANET have been described. To summarize this work, the trend is definitely to go toward an environment with capability to create realistic mobility models with high degree of realism in the modeling of vehicular mobility.

Network and traffic simulators have been gaining much attention because they are the tools used by the researchers and other actors such as the automotive industry to fid or get how these VANETs behave in different scenarios.

III-6- Hybrid Simulator

The network and mobility models have frequently been decoupled in two separated simulation tools. In fact, high-quality simulators exist in each of these areas like those explained earlier.

There are many reasons why VANET researchers are interested in developing new simulators in which mobility and communications are coupled. With this purpose, there is a clear need for an integrated mobility and network simulator in order to evaluate effectively the performance of VANET systems.

III-6-1- Traffic and Network Simulator Environment

Traffic and Network Simulation Environment (TraNS) links two open-source simulators, NS-2 and SUMO. The purpose of TraNS is to avoid simulation results to differ significantly from those obtained in real environments. TraNS [64] has two modes of operation: (1) network-centric mode that is used to realistically evaluate the mobility of nodes and communication protocols for VANET, and (2) application-centric mode that is used to evaluate applications for VANET. The development of TraNS is suspended. Hence, TraNS does not support the latest version of both SUMO and Ns-2. Currently, TraNS cannot provide any support. But it is possible to generate mobility traces for NS-2 using TraNSLite.

III-6-2- GrooveNet

GrooveNet is an integrated simulator that allows communication between a simulated vehicle and a real vehicle to model inter-vehicular communication with a topology map.

GrooveNet [65] is a modular event-based simulator with well-defied model interfaces that make adding models easy. It supports multiple vehicles, trips, and mobility models over a variety of network links and physical layer models, including simple car-following, traffic lights, lane changing, and simulated GPS models. GrooveNet supports three types of simulated nodes: vehicles that are capable of multihopping data over one or more DSRC channels, fixed infrastructure nodes, and mobile gateways capable of V2V and V2I communications.

Also GrooveNet supports multiple network interfaces for real V2V and V2I communications. It is able to connect to the vehicle's on-board computer and read OBD-II diagnostic codes.

III-6-3-NCTUns

NCTUns is a software for the modeling of microscopic traffic and network simulation that works as emulator with the ability to simulate various protocols used in both wire and wireless networks in IP networks. Regarding network devices and protocols, NCTUns supports for wireless LAN networks, wireless mesh networks, GPRS networks, quality of service (QoS) DiffServ networks, RTP/RTCP/SIP VoIP protocols, and several other wireless standards such as IEEE 802.11(e). QoS protocols have been added to NCTUns [66].

An important aspect is that NCTUns supports emulations distributed on multiple computers in a large network, for situations in which the emulated network has many nodes with real-world applications that need to connect to the network. NCTUns can partition an emulated network into smaller parts so that they can be simulated on different computer machines automatically and transparently. In addition to the preceding characteristics, NCTUns also uses the TCP protocol and Linux to achieve greater flexibility in the simulation results.

III-6-4-MobiReal

MobiREAL is a network simulator for ubiquitous environments through mobile devices that can simulate real movements of people and vehicles with the ability to change their behaviours depending on the context of the application with which a more detailed evaluation of performance can be achieved for VANET. MobiREAL makes modeling nodes through C++ and adopts a probabilistic rule-based model to describe the behaviour of the nodes.

MobiREAL [67] provides a suite of useful tools with a visualization tool called an animator. The animator can visually animate the movement of nodes, network topology, and packet propagation, and so on and can also show statistical information like node density and the packet error rate observed in each subregion. Therefore, it can easily be applied to create trace-based mobility scenarios supported by many other network simulators.

This feature allows users of the other simulators to receive the benefit of realistic mobility scenarios. MobiREAL is basically a MANET simulator and provides a methodology to model and simulate more realistic movement of the nodes. Although it is focused on the applications of MANET, it can be applied to VANET.

III-6-5- MobiTools

MobiTools is an integrated VANET tool chain [68]. MobiTools is composed of MobiView, a QualNet mobility visualizer based on NASA World Wind; MobiMap, a web front end that graphically, via Google Maps API, supports the use of TIGER census data; MobiDense, a vehicular traffic simulator that builds on known flow intensities on streets and turns probabilities at intersections to create mobility traces; and MobiRay, a propagation simulator tool capable of predicting the effects of reflections on buildings and on the ground. The main idea behind this tool is to provide the research community with an easy-to-use, accurate mobility engine.

III-7- Conclusion:

VANET is an important application of communications and networking. VANET leverages the potentially transformative capabilities of wireless communications and networking to make surface transportation safer, smarter, and greener.

Various VANET applications have been developed to improve traffic safety, mobility, and environmental protection. Before large-scale deployment of VANET technologies, these technologies and applications must be tested in a real-world environment. Field tests are the best way to serve the needs of testing activities. However, high cost is usually required for establishing test beds and performing field tests, particularly if a large number of vehicles are involved. A low-cost alternative to field tests is simulation, which could evaluate the performance of most VANET applications under close to real-world operating conditions. In practice, field tests and simulation complement each other to complete a VV&E process in which simulation is conducted for verification firstly and then field tests are conducted for validation.

The simulation of VANET consists of a communication network simulator and a traffic simulator. In this chapter, firstly the state of the art and practice of VANET is given; then the communications and networking of VANET is presented. The main body of this chapter is focused on the review of various communication network simulators and traffic simulators for VANET. For each simulator, its mechanism, strength, and weakness are reviewed. It is expected that simulation remains a powerful tool to evaluate the performance of a VANET application and validate the assumptions.

Chapter IV Experiments

IV-1- Simulation

IV-1-1- Simulation Information

In this party, we use OMNeT++ which is an object-oriented modular discrete event network simulation framework. It has a generic architecture, so it can be used in various problem domains as stated in the previous chapter, Modules can be connected with each other via gates (other systems would call them ports), and combined to form compound modules [77]. The depth of module nesting is not limited. Modules communicate through message passing, where messages may carry arbitrary data structures. It can pass messages along predefined paths via gates and connections, or directly to their destination; the latter is useful for wireless simulations, for example. Modules may have parameters that can be used to customize module behaviour and/or to parameterize the model’s topology.

OMNeT++ simulations can be run under various user interfaces. Graphical Figure IV.09, animating user interfaces are highly useful for demonstration and debugging purposes, and command-line user interfaces are best for batch execution.

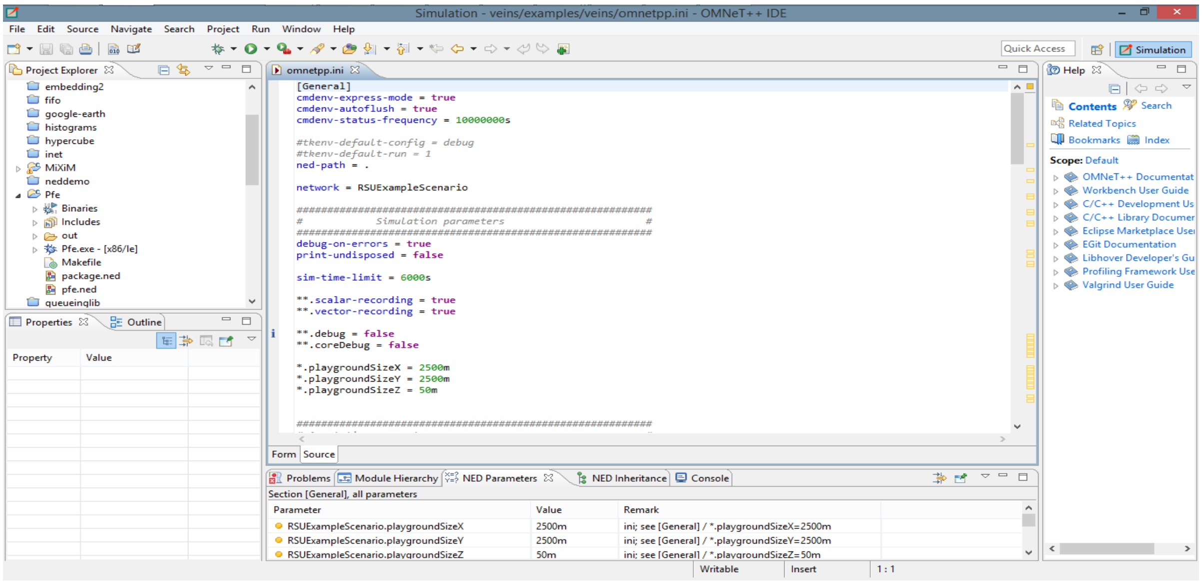

Figure IV.08: OMNeT interface.

The simulator as well as user interfaces and tools are highly portable. They are tested on the most common operating systems (Linux, Mac OS/X, Windows), and they can be compiled out of the box or after trivial modifications on most Unix-like operating systems.

The OMNET ++ tool has several advantages as stated before consequently, we prefer to use this simulation tool to avoid several problems related to the implementation of the simulation model by other simulators, especially when a large number of messages exchanged and shared between network nodes. the version used here of simulator OMNET ++ is version: 4.6. In addition, we used the traffic simulator “Simulation of Urban Mobility (SUMO) “version 0.25.0, which was explained in the previous chapter and the framework for vehicular network simulations “Veins Version 4.4 to achieve our results.

IV-1-2- Veins

Veins, the Open Source vehicular network simulation framework, ships as a suite of simulation models for vehicular networking. These models are executed by an event-based network simulator (OMNeT++) while interacting with a road traffic simulator (SUMO) as shown in Figure IV.09. Other components of Veins take care of setting up, running, and monitoring the simulation. This constitutes a simulation framework. What this means is that Veins is meant to serve as the basis for writing application-specific simulation code. While it can be used unmodified, with only a few parameters tweaked for a specific use case, it is designed to serve as an execution environment for user written code. The framework takes care of the rest: modeling lower protocol layers and node mobility, setting up the simulation, ensuring its proper execution, and collecting results during and after the simulation [78].

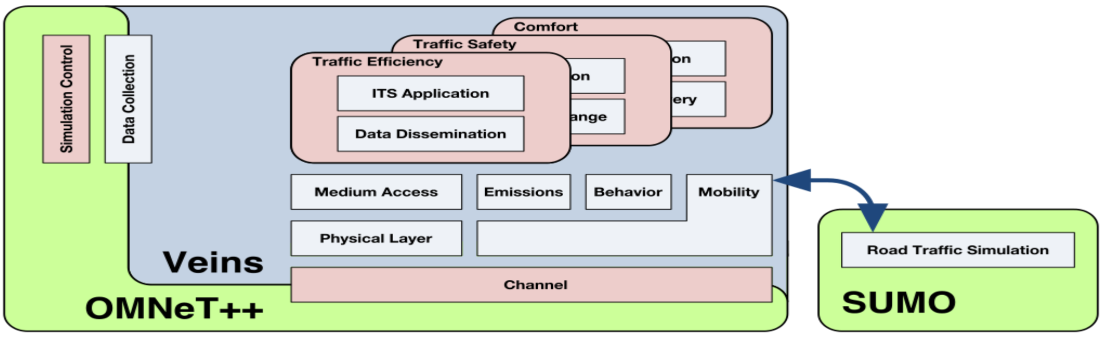

Figure IV.09: Veins architecture

As discussed before, with Veins each simulation is performed by executing two simulators in parallel: OMNeT++ (for network simulation) and SUMO (for road traffic simulation). Both simulators are connected via a TCP socket. The protocol for this communication has been standardized as the Traffic Control Interface (TraCI). This allows bidirectional-coupled simulation of road traffic and network traffic. Movement of vehicles in the road traffic simulator SUMO is reflected as movement of nodes in an OMNeT++ simulation. Nodes can then interact with the running road traffic simulation.

IV-1-3- Experiments

In our study, it is obvious that evaluating all the existing protocols by simulating them, is kind of impossible because of the time delay. Instead, we chose one of the protocols mentioned above and we simulate its behaviour using OMNET++ and SUMO.

The chosen protocol is: Abiding Geocast in which vehicles should be equipped with a location device, omnidirectional radio antennas of transmission range R. Communications between vehicles are supposed to be bidirectional, and are based on the broadcasting of messages. When an emergency situation occurs Figure IV.11, one vehicle which detects this problem starts broadcasting a warning message to inform the other relevant vehicles about the danger.

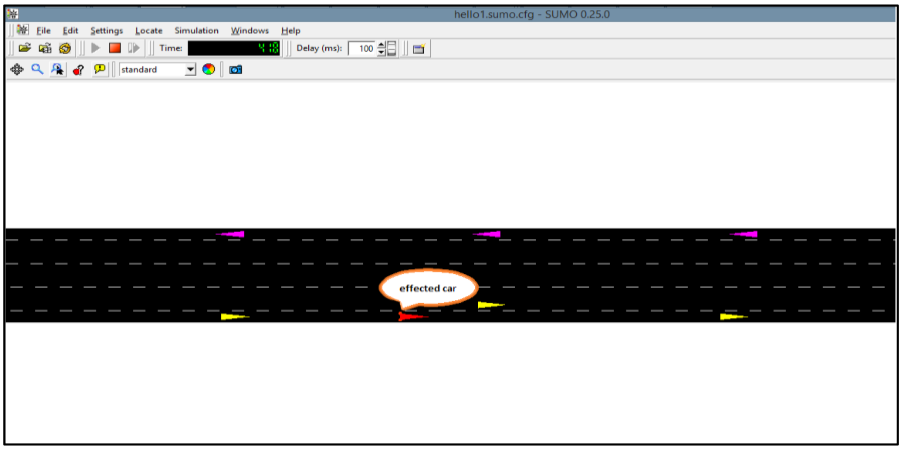

Figure IV.10: Simulation of Emergency situation with SUMO

The warning information is characterized by the event topic, content, location, safety distance, and time limit, etc, where safety distance means that vehicles moving towards the event should be informed at least distance away from the event and time limit is the validity of the warning event.

In this system two strategies are used to improve its efficiency: (1) vehicles travelling in opposite direction are used as relays to overcome fragmentations, (2) the waiting time is set dynamically for the next broadcast when the massage is received.

The protocol uses the notions of effect line to indicate beyond which point vehicles will become inactive and effect distance which is the distance between safety line and effect line.

A. Simulation set up

The parameters of are listed in Table IV.03. For all the simulations, we fix the length of the straight road to 6 km, and assume one vehicle can overtake other vehicles freely. The location of the warning event is at 50 meters, and the safety distance is 550 meters. For all the runs, simulation time is 5000s, the start time of the warning event is at 400s, and it will last to 5000s with the valid duration 60 minutes. We omit the first 500s to let the system reach a stable state considering the distribution of vehicles over the road. When the warning event occurs, the beginner of dissemination is at the location of the safety line.

Table IV.03: Simulation parameters

Description	**Value**
transmission range (R)	250 m
safety distance	550 m
speed mean (S_{mean}) speed variation ε	30 m/s 5 m/s
traffic volume α	200 ~ 1000 (veh/hr)
effect distance factor β	6.0 ~ 9.0

B. Result and Discussion

We evaluate the performance of the warning message dissemination model under different scenarios; mainly check the role of two parameters α and β on the broadcast overhead. Firstly, we will check how the effect distance factor β influences the broadcast overhead.

From the result in Figure IV.11, we can see that a smaller β will cause higher probability of warning message loss as showed in Table II. With the traffic volume varying from 200 to 1000 veh/hr, the model can guarantee no warning message loss when β is over 8.0.

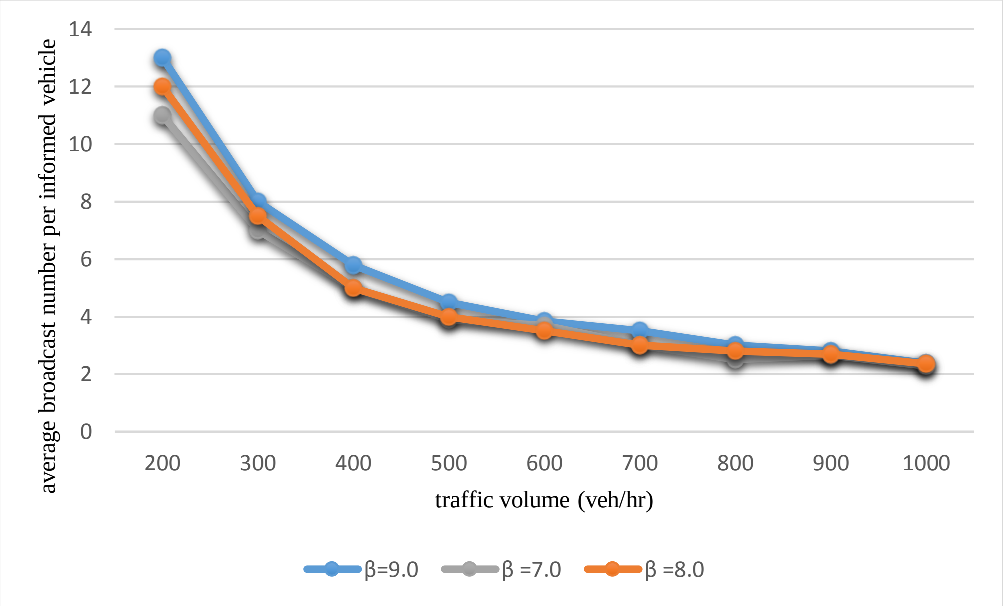

Figure IV.11: Broadcast overhead under different scenarios

As we see from Figure IV.11, the average broadcast per informed vehicle declines with β and increases with β. This means that the broadcast overhead in a dense network is lower than that in a sparse network, because one vehicle in a dense network will receive message from other vehicles with high probability, then it can wait and save broadcasts. Increasing β will result in more broadcasts, because vehicles will broadcast more before passing the effect line and stop broadcasting. When β is equal to or more than 8, we can keep the warning message in the affected area during its lifetime. Note that we do not study delivery time as a performance metric, since we are interested in delivery before a vehicle cross the safety line.

Table IV.04: Impact of effect distance factor

effect distance factor β	6.0	7.0	8.0	9.0
probability of message loss	8.15 %	0.74 %	0	0

The delivery ratio is 100% if the effect distance factor β is sufficiently large (see Table IV.03). Figure IV.12 shows that the total broadcast overhead, i.e., for all vehicles, is about 0.6 times per second for varying traffic volume. The overhead less depends on traffic volume, so this model is practicable in dense and sparse network. Compared with the capacity of wireless LAN, the overhead is low.

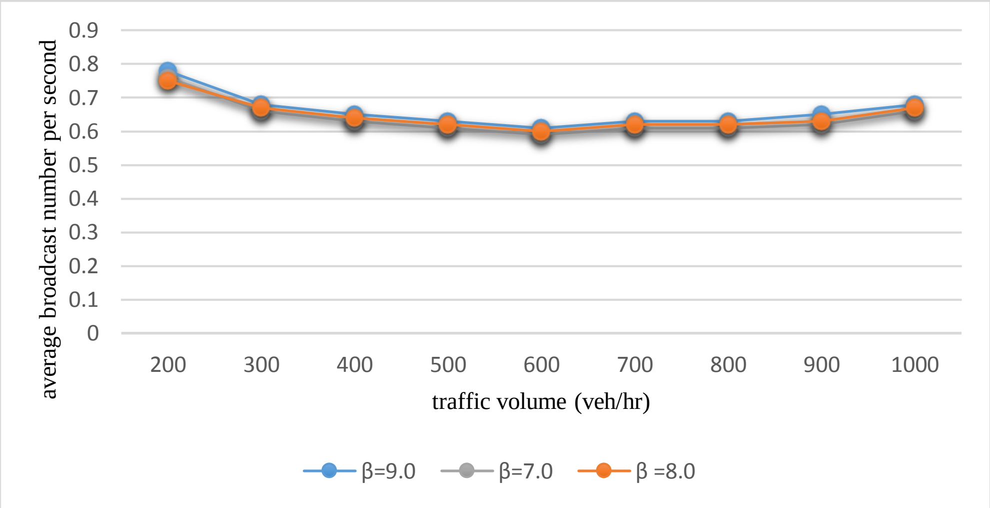

Figure IV.12: Broadcast overhead in unit time

IV-1-4 Conclusion:

In this chapter, an analysis is done on various data dissemination protocols. The previous study shows that there are three types of data dissemination protocols named broadcasting based, multicasting and geocasting based. These protocols reveal that different disseminating techniques are used in different scenarios i.e. some protocols are beneficial for propagating data in urban areas while some are beneficial for highways. We have introduced one of them which is abiding geocast.

Each protocol has its own pros and cons. The analyse reveals that to disseminate maximum data over vehicular networks by utilizing minimum bandwidth and to disseminate data in urban areas is a challenging task. These problems are addressed in the reviewed protocols. Each protocol has its own way to deal with these problems. The future idea is to find out the problems of any of these protocols and try to address those found problems.

General Conclusion

Intelligent transport systems are in their infancy. The development of new the technologies has fostered a tremendous evolution of vehicular networks. This change aims to make networks more efficient, more reliable, safer and more environmentally friendly as well from the perspective of the automotive industry as network and service operators.

Vehicular networks are an extension of MANET networks, allowing data exchanges vehicle to vehicle or vehicles and infrastructure. They aim to improve the safety and efficiency of road transportation and improve user comfort by offering various services such as Internet access, the decision supports and guidance.

Our objective was to analyse the mechanisms and the protocols adapted to the characteristics of these networks o.

First, we presented the main concepts, and specific challenges related to vehicle networks. We also presented the dynamics around such networks but specially to assimilate the necessary basis for understanding the functioning mechanisms and bases of vehicular networks.

From the results we have obtained, we concluded that the data dissemination plays a very important role in studying the performance of a vehicular networks. Therefore, it is necessary to choose a disseminating protocol so that the simulation results are reliable.

Our field of study is focused on the coverage measurement of data dissemination in a VANETs. To achieve our goal and get simulation results closer to reality, we implemented a mobility model for VANET network and we tested - in this network – the Abiding Geocast protocol.

Perspective

Through this thesis, we were able to understand and assimilate different stages that a research project should move forward. We also acquired an internal experience and a good overview of the methods of work of a researcher, with extensive knowledge in this field.

Throughout this work we have developed techniques and promising new ideas that will allow us in the near future to expand this research topic and address the most demanding challenges in the VANETs.

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