Republic of Iraq
Ministry of Higher Education
and Scientific Research
University of Babylon
College of Information Technology
Department of Information Networks

A priority Queuing Model to Improve Data Transmission in VANET

A Thesis
Submitted to the Council of the College of Information Technology for Postgraduate Studies of University of Babylon in Partial Fulfillment of the Requirements for the Degree of Master in Information Technology-Information Networks

BY

Nibras Abdulridha Hamed Mousa

SUPERVISED BY

Prof. Dr. Saad Talib Hasson Aljebori

2023 A.D. **1444 A.H.**

بسم الله الرحمن الرحيم

﴿قَالَ بَلْ سَوَّلَتْ لَكُمْ أَنفُسُكُمْ أَمْرًا فَصَبْرٌ جَمِيلٌ عَسَى
ٱللَّهُ أَن يَأْتِيَنِى بِهِمْ جَمِيعًا إِنَّهُ هُوَ ٱلْعَلِيمُ ٱلْحَكِيمُ﴾

سورة يوسف(83)

صدق الله العظيم

Supervisor Certification

I certify that the thesis entitled “(A priority Queuing Model to Improve Data Transmission in VANET)” was prepared under my supervision at the department of Information Networks / College of Information Technology/ University of Babylon by (Nibras Abdulridha Hamed) as partial fulfilment of the requirements of the degree of master in information technology-Information Networks.

Signature:

Supervisor Name: **Prof. Dr. Saad Talib Hasson**

Date: / /2023

The Head of the Department Certification

In view of the available recommendations, I forward the thesis entitled “A priority Queuing Model to Improve Data Transmission in VANET” for debate by the examination committee.

Signature:

Prof. Dr. Saad Talib Hasson

Head of Information Networks Department

Date: / /2023

Dedication

To My Parents

To my supervisor Prof.Dr.Saad Talib Hasson

To my supporter Randa

To My best Friends

{Ream, Dhuha, Huda, Aya}

To everyone who supported me and move me forward

With All My Respect And Love…

Nibras Abdulridha

Acknowledgement

First of all, I would like to thank Allah, without his care I could never have contemplated all the work involved in this study.

I would like to offer my sincere thanks and appreciation and gratitude to my supervisor Prof.Dr. Saad Talib Hasson, for his help and support during the period of my study, he is the pillar of my work.

Special thanks to Dr. Firas Sabah for his continuous giving during my study of courses and in the field of research, support and encouragement for me until I completed my work.

Many thanks and gratitude to the doctors who helped me during my academic and research career.

My colleague Randa, thank you uniquely and sincerely for what you gave me throughout my career and for standing with me in my sorrow, joy and despair. Thank you for always being my hope. I love you.

Finally, thanks to my friends as being an important source of motivation for me to make everything worthwhile.

Abstract

In recent years, research on Intelligent Transportation Systems (ITS) has increased due to its importance in simulating real-life scenarios to provide transportation around the world. Vehicle networks (VANET) are another concept of intelligent transportation systems that are an extension of wireless network.

The structure of vehicular networks is a challenge due to the continuous change in the movement of vehicle with time. On the other hand, vehicles exchange messages with each other and with roads to communicate with each other about road guidance or problems, as well as the use of various applications such as safety and entertainment applications, etc. The messages in VANET are of several types, including safety and unsafety messages, the safety message which must be sent quickly before the rest of the unsafety messages, such as speeding messages, determining the location, and others.

In this thesis, an approach was sought to provide safety messages with the fastest possible way and with several levels of priority. A new clustering method based on Roadside Units (RSU) was also proposed, where the road was divided into a group of regions represented by clusters, and in each cluster the RSU is the basis (head) of the cluster. The messages were divided into three sections according to the degree of importance (emergency message, important message, and normal message), and a protocol was built that works on the principle of providing service according to their priority.

The results showed that the proposed approach was more stable in terms of clusters, since the head of the cluster (RSU) is fixed in it, compared to previous research that referred to building clusters that are more stable. The results also showed a greater possibility of processing emergency and important messages faster and better than normal messages of less importance.

List of Abbreviations

ITS	**Intelligent Transport Systems**
VANET	**Vehicular Ad Hoc Network**
MANET	**Mobile Ad Hoc Network**
V2V	**Vehicle To Vehicle**
V2I	**Vehicle To Infrastructure**
V2X	**Vehicle To Everything**
OBU	**On-Board Unit**
RSU	**Roadside Unit**
DSRC	**Dedicated Short Range Communication**
GPS	**Global Positioning System**
TMC	**Traffic Management Center**
IEEE	**Institute of Electrical and Electronics Engineers Standards**
RTT	**Round Trip Time**
RSA	**Rivest-Shamir-Adleman**
ECDSA	**Elliptic Curve Digital Signature Algorithm**
CCTV	**Closed Circuit Television**
AOMDV	**Ad hoc On-demand Multipath Distance Vector**
FF-AOMDV	**Ad Hoc On Demand Multipath Distance Vector with the Fitness Function**
EGSR	**Eastern German Shepherd Rescue**
ISR	**Institute of Species Research**
QMR	**Quality Management Representative**

Table of Contents

List of figures

List of tables

List of Symbols

CHAPTER ONE

Introduction

1 CHAPTER ONE
Introduction

1.1 Overview

Intelligent Transportation Systems (ITS) refer to various communications and information technology to provide transportation solutions and different services in a convenient, effective, efficient and safe way to provide safety in different environments (Susana, et.al, 2017). ITS work as an integrated system containing vehicles, infrastructures, roads, users, etc. ITS linking various engineering sciences, technology, computer science, systems analysis, road improvements and updates. The use of modeling techniques in solving transportation problems represents a major challenge. Modeling is supporting the ideas to control these systems and facilitate transportation for users. Such technique is making the user aware of the road conditions and using them in a more coordinated, safe and intelligent way (Ramesh, et. al, 2022).

The transport system uses wireless communication because it supports the feature of moving and communicating through the air as a carrier medium with the possibility of communication at anytime and anywhere (Susana, et.al, 2017). The node in the transport networks moves at a high-speed during time and goes through many connections and disconnects with other nodes. Regular wireless networks contain forwarding devices such as base stations, routers or access points distributed on the network. In wireless ad hoc networks, communication between nodes is performed without these devices (Julio, et. al, 2016).

Vehicular ad hoc networks (VANET) plays a vital role in promoting the concept of Intelligent Transport System (ITS) (Ali Raza, et.al, 2021). Vehicles are equipped with radio communication devices such as the IEEE standard

802.11 and Dedicated Short Range Communication (DSRC) and Vehicle Positioning Devices (Global Positioning System GPS) (Susana, et.al, 2017).

Communication in intelligent transportation systems, or what is also called VANET is done using several methods, including main types, which are the communication between one vehicle and another called Vehicle To Vehicle (V2V), and this is done through the integrated units called an On-Board Unit (OBU) present in each vehicle and it is considered as a one-to-one communication, and the other type is the communication between a vehicle and the infrastructure (Roadside units) called as Vehicle To Infrastructure (V2I), and this is done when the vehicle wants contacting vehicles located outside of its range and obtaining alerts or information located far from them, or when there is no other vehicle that can communicate with. There are other types of communications in which the vehicle can communicate with anything around it, and this concept is called communication between the vehicle and everything (V2X). also, communication between RSUs called Infrastructure to Infrastructure (I2I) (Susana, et.al, 2017).

After achieving contact, the communication process begins by sending messages for various purposes, such as the occurrence of congestion, accidents of all kinds, or alerts of the occurrence of certain events on the roads (Jiří, et.al, 2021). These messages are of several types, including important and urgent, which must be sent quickly before the rest of the messages that are normal, such as speeding messages, determining the location, and others (Judith, et.al, 2022). These messages are sent between the integrated units (OBU) on the vehicles, which act as a transmitter and a receiver of vehicle information, and between these units and the Roadside Units (RSU) that are distributed on the road in an organized manner to cover different areas of the road. RSU is deployed to achieve the best possible coverage. This process enhances communication capabilities and fulfills ITS demands (Jiří, et.al, 2021).

In this thesis, data transmission rate optimization is discussed by ensuring that the vehicle connection is properly obtained to transmit information in order to increase the connection and coverage of vehicle links, as well as reduce link failures as much as possible. To achieve this, the central cluster approach based on roadside units was proposed. At the same time, messages are filtered in order to ensure that emergency messages arrive in the first place, then important messages in the second place, and the rest of the messages are treated as regular messages, and thus messages are transferred according to their priority during transmission**.**

The principles for ad-hoc vehicle networks are presented in this chapter. It highlights techniques for data dissemination in ITS. This chapter consists of seven sections, including an introduction. The following section provides a brief illustration of some of the backgrounds. The problem statement and the aims of this project are defined in the third section. The fourth section shown the context and motivation. The characteristics and challenges and Modeling Mobility and Simulation of VANETs will be discussed in section five, named literature review. The sixth section is to mention the Thesis Objectives and Contributions. Finally, the Organization of this thesis will be concluded in the last section.

1.2 Communication with VANET

All over the world, transportation and road problems are among the most important major problems for ITS or VANET. Research continues to find solutions to these problems because smart transportation simulates technology and needs to always evolve, and when one says “development” this means updates that result in new problems that need continuous improvement to reach the optimal behavior of the network.

Transportation problems are considered sensitive because they threaten the lives of people, whether they are drivers, passengers, or people on the roads (Judith, et.al, 2022). Among these problems are accidents caused by vehicles on roads. And the most important causes of these problems in transportation is the behavior of drivers and how they drive vehicles in the correct way by the reality of the methods with confirmed, reliable and accurate facts. This is done by means of VANET or ITS modern and advanced. These technologies consist of nodes (vehicles) that move continuously and at different speeds on the roads within the laws that regulate their movement (Susana, et.al, 2017).

Traffic Management Centre (TMC) plays a fundamentally vital role in Intelligent Transportation Networks, as it is managed by a private transport authority. Data is collected from various vehicles or roadside units and sent to the center for collection and analysis to obtain important results and statistics about roads and vehicles. Then return the results to the intended destinations.

Figure 1.1 shows a simple representation of the traffic management center (Ahmed, et.al, 2019).

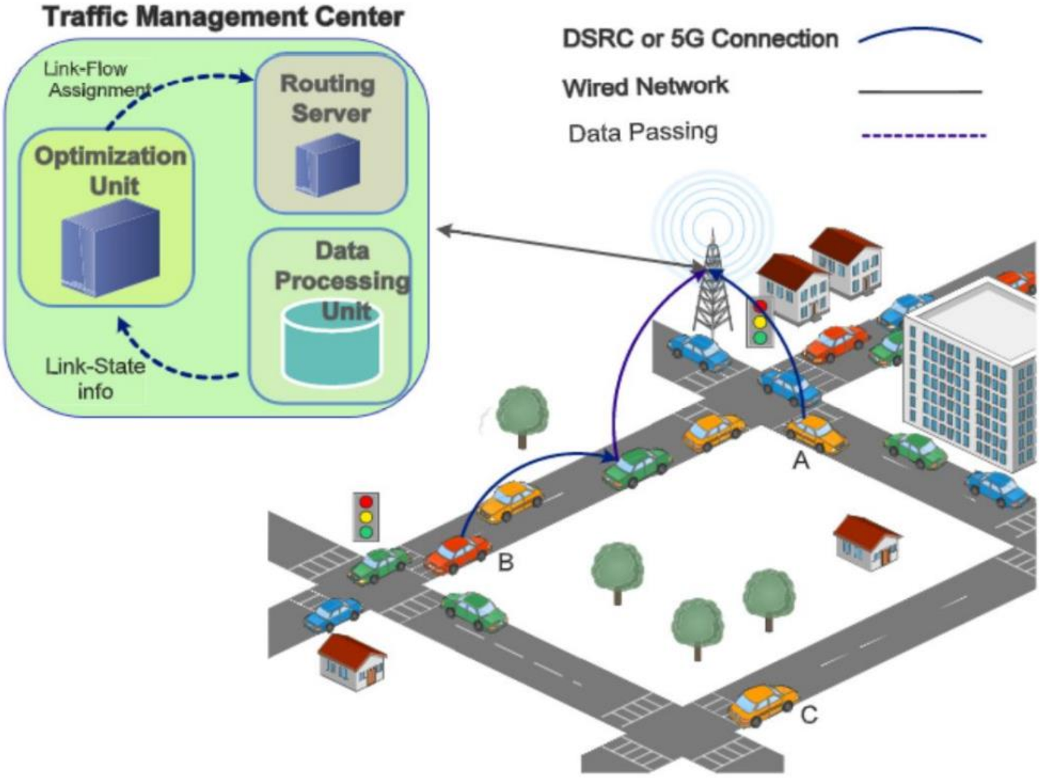


Figure 1.1 Traffic Management Centre (Abuashour, 2017)

One of the most important units of communication between vehicles and roadside units is messages. The issue of transferred these messages from the source to the destination is one of the most important aspects that must be taken into consideration in order to deliver them in a correct manner using several protocols (Mohammed and Zsolt, 2020). Research is still underway to improve these protocols and deliver them in a better way (Ahmed, et.al, 2019). It also considers the problem of classifying these messages in order to send important messages first (such as accident and disaster messages, emergency vehicles crossing such as ambulances, fire trucks, police cars, etc). It represents a critical point for the roads to deal with disasters, to reduce accidents, and to preserve the safety of people in the first place, then the safety of vehicles and roads (Mohammed and Zsolt, 2020).

1.3 Problem statement

High density cases in vehicles causes congestion in transmission channels, and applications suffer from deterioration in work and performance. To improve the data transmission in a reliable and safety manner, all conditions and problems in the channels must be taken into account, and sufficient connectivity and coverage must be maintained to keep the vehicles connected and “link failure” does not occur.

Data is transmitted in vehicular networks by exchanging messages between them and roadside units. The contents of these messages vary according to their purpose, such as alert messages, notifications, inquiries, and so on. The types of these messages fall into two main types: safety and unsafety messages. Studies are still ongoing to find a better approach to transmit safety messages in a faster way to keep up with the speed of vehicular networks.

In a very short time, a lot of information is exchanged between vehicles or between vehicles and roadside units. It is difficult to verify the arrival of all messages, and here safety messages may be lost, which are sometimes emergency messages and are very important that they require immediate transmission. Here, a specific mechanism must be found for messages to arrive and be delivered according to their priority (multiple levels of priority); that is to send first the emergency messages, such as accident and disaster messages on roads and vehicles, and then to send important messages that include road congestion messages or a request for crossing of emergency vehicles (fire trucks, ambulances, Rescue cars, police cars, etc.), and the rest of the messages can be classified as normal messages, such as speed limit messages, location, and so on.

1.4 Thesis aim

The main aim of this thesis is to develop a network model of vehicles and roadside units that is able of improving the data transmission by ensuring the connectivity of packet passing regardless of the high traffic density, and ensure that emergency and important messages arrive first before normal messages to maintain the safety of roads, vehicles and drivers.

This aim can be achieved through addressing the following objectives: -

- ✓ Solving the problem of losing emergency and important messages during the packet transfer over the network.
- ✓ Proposing a developed center spatial cluster-based approach based on RSU.
- ✓ Proposing queuing network models to represent the VANET environment.
- ✓ Analyzing the transmitted messages of the moving vehicles.
- ✓ Analyzing and classifying the VANET's messages and giving them a priority level.
- ✓ Evaluating and comparing the results of the suggested approach with metrics of data dissemination and queuing strategy in different models and with other approaches.

1.5 Related work

Over the years, several approaches have been presented to improve the data transfer rate in several aspects, including improving the performance of data communication in VANETs and paying attention to sending messages with higher priority in several ways, algorithms, and various protocols.

1.5.1 Clustering Approach

Lin, et. al, (2016) proposed a protocol based on mobile vehicle-to-vehicle communication. It is based on vehicle-to-vehicle communication only and does not work with other types of communication such as (vehicle-to-infrastructure). Where clusters of compounds with the same moving patterns were formed in clusters. In each cluster, a vehicle is elected to be the main one in that cluster, and its mission is to manage communications and exchange information messages with its members. One of the problems with this proposal is that the chance of congestion in the same cluster is greater, and this causes delays and loss of exchanged packets, as well as high costs in terms of energy for the main vehicle of the cluster (Lin, et.al, 2016).

Lucas, et.al, (2017) proposed a delay-based network-based geo-clustering method to overcome traffic congestion in vehicle networks. They applied the approach to heavy congestion and vehicle congestion in the form of clusters, where each cluster constitutes basic links in every part of the road. They applied their approach to propose mechanisms between networks and outside networks in order to achieve the transfer of information in traffic. They relied on the use of the Internet and the Global Positioning System (GPS), this approach required complex calculations (Lucas, et.al, 2017).

Abbas, et. al, (2019) proposed a "priority-based direction-aware media access control (PDMAC)". Their proposed protocol was based on synchronizing the internal and external clock time of the cluster. Their work was based on the use of multiple priorities with three levels to improve the transmission of warning messages in the network. They take into consideration the direction, type, and security level of the message for each level. They claimed that their proposed protocol outperformed previous proposals in terms of delivering packets, reducing message loss and throughput (Abbas, et. al, 2019).

Shah, et. al, (2019) proposed a technique in order to maintain the emergency messages on the network in the fastest way and the least number of delays such as road accidents and disasters using clustering. Through this approach, they worked to reduce the problems faced by the broadcast storm of the messages exchanged within the VANET networks to reduce congestion in the network. This approach provides good results in terms of delay in sending emergency messages, but it faces a problem of poor performance whenever the number of network connections is less in the event of an increase in vehicle speed (Shah, et.al, 2019).

Cheng, X., & Huang, B. (2019) introduced an algorithm based on central clustering in vehicle networks. Where they are self-organizing in the form of groups, each group represents a cluster containing the head of the cluster that is selected, which is connected to a group of cluster members to reduce the impact of traffic jams. In turn, the head of the cluster is connected to the road architecture (roadside units). The proposed algorithm is applied on highways, and the results show high stability and better packet loss rate (Cheng, X., & Huang, B. (2019).

Tseng, et.al, (2019) suggested a way to overcome the problems of clusters at intersections in terms of changing the direction of vehicles and the speed of movement with the help of infrastructure architecture (roadside units). Because most of the cluster approaches depend on the basis of their work on clustering and roads with the same groups of similar characteristics, they studied each road at the intersections on the basis of the average delay from end to end. They applied multiple scenarios in high- and low-density roads where the information of vehicles network transmitted based on the roadside units from one intersection to another (Tseng, et.al, 2019).

Bersali, et.al, at 2020 proposed an algorithm based on collaborative clusters with the use of the Internet of Vehicles named "A New Collaborative Clustering Approach for the Internet of Vehicles (CCA-IoV)", in order to use the capabilities of the Internet, especially cloud computing and storage, which are important in modern vehicles for the implementation of clusters. The proposal is based on the use of clusters for collaboration between vehicles in the vehicle network rather than in communication with remote servers (Bersali, et.al, 2020).

1.5.2 Priority of Data Dissemination Approach

Taherkhani and Samuel Pierre, (2016) They suggested multiple priorities for service-type messages based on the message's load, type, size, and network status. These factors are classified into fixed or dynamic factors. Their proposed strategy schedules messages and checks them based on the mentioned factors. Perfectly applied to urban environments and highway scenarios (Taherkhani and Samuel, 2016).

Kittipiyakul, et.al, (2018) relied on the use of information about the destination, including direction, location, relative time and proximity between other vehicles in order to reduce the number of messages that are classified as unimportant, such as messages of some vehicles that cannot cause an accident. Their results showed that their proposed scheme can verify the messages of nearby vehicles with less packet loss and less delay compared to other schemes. The results also show that it provides greater awareness of nearby cars (Kittipiyakul, et.al, 2018).

Ghaemi, et. al, (2021) proposed an improved protocol based on time delay. This protocol is able to determine the optimal path for delivering the packet through the least delay time. Their protocol calculates the RTT in the entire network and then makes a table of all the RTT paths in an ascending order. When one of the shortest routes fails, the RTT moves to the next one. Their protocol also gave priority to sending important messages over normal messages. (Ghaemi, et.al, 2021).

Yang, et. al, (2022) proposed a protocol based on the MAC layer and called it PHB-MAC. It relies on the use of conflict to prioritize messages according to several criteria to keep important messages from being lost and to ensure that they are sent. They claim that their improved protocol gives better throughput by 30% than previous protocol (Yang, et.al, 2022).

Bilal, et.al, (2023) proposed a model called Beacon-oriented Emergency Message Dissemination (BEMD), using a proposed technique for enhancing vehicle coverage in order to transmit emergency messages with the least possible delay. The goal of their proposal is to communicate towards the beacon in highway scenarios for both high- and low-density commuting. In their scenarios, they relied on the density of sending emergency messages, and showed better results in terms of coverage, information delivery, and the rate of packet distribution (Bilal, et.al, 2023).

1.6 Organization of the Thesis.

This thesis is organized into five chapters as follow:

- **Chapter one:** presents the current data dissemination issues; then, we briefly describe the background, purposes, structure, overview of the unique characteristics of vehicular communications, and motivation of this research work. Finally, the modeling and simulations in VANET.
- **Chapter two:** describes the Fundamentals of VANET, and the existing data dissemination approaches to show their limitations/drawbacks.
- **Chapter three:** presents the proposed data dissemination-based – Routing and queuing approach in VANET.
- **Chapter four:** evaluates the proposed system performance by using Net Logo simulation; Studying the results and analyzing them fully.
- **Chapter five:** includes the thesis conclusion and future work directions.

CHAPTER TWO

Theoretical Background

2 CHAPTER TWO
Theoretical Background

2.1 Introduction

In intelligent transportation systems, drivers on the road feel more comfortable because they are dealing with an intelligent system that provides them with greater knowledge of the road and avoids accidents and disasters that most often lead to the loss of their lives (Julio, et.al, 2016). Smart systems also provide them with a variety of services, such as taking care of safety, entertainment applications, and others. These services and applications need to provide working mechanisms that suit them and simulate vehicle network environments which are characterized by rapid change in their architecture (dynamic structure), fast vehicle movement, and frequent outages on the roads. Therefore, we need to reach as much as possible a more stable state of the network in terms of coverage and connectivity and avoid link failure (Sepideh, et.al, 2020).

This chapter is organized as follows: Section 2 describes Intelligent Transport System and its strategic. Section 3 refers to Communication Systems techniques in VANET. Section 4 describes VANET and its applications. Section 5 reviews data dissemination in VANET. Section 6 refers to Queuing Models and Section 7 describes Performance metrics.

2.2 Intelligent Transport System

In fact, Intelligent Transportation Systems (ITS) is another name for ad-hoc Vehicle Networks, which falls under the concepts of wireless networks (Ali Raza, et.al, 2021). Research has increased recently on the use of these systems to improve transportation due to their importance in real life to provide improvements to the current transportation systems as shown in figure 2.1 (Julio, et.al, 2016). In all types of dedicated wireless vehicle networks, the network structure is variable due to the movement of nodes over time, which requires the occurrence of a new link structure, and so on. Networks of dedicated vehicles suffer from this problem in particular because the vehicles in them move at very high speeds and are subject to many changes. (Ramesh, et.al, 2022) Time plays an important role in intelligent transport systems in communication, data exchange and message processing between parts of the network. In urban environments where the number of vehicles is variable and is subject to continuous increase, which leads to traffic jams, intelligent transportation systems display information about congestion, traffic signals, and road paths for drivers to avoid congestion as much as possible (Sepideh, et.al, 2020).

Figure 2.1 Global Smart Transportation

In vehicle networks, IEEE802.11p acts as a standard for OBU communication in vehicles with RSU within a range of 300 to 1000 meters (Ramesh, et.al, 2022).

It is also important for these networks to exchange data and maintain an optimized transmission rate to deliver disaster messages immediately to prevent fatalities and maintain network security as well as taking care of vehicular and emergency vehicle traffic problems.

2.2.1 Strategic Planning for ITS Implementation

The general strategy for ITS work depends on three main phases, as shown in figure 2.3, into:

Data collection: At this stage, all data are collected from transport systems in general, which need to be fast data that parallels the speed of transport within the systems, as well as accurate, wide, and real-time synchronization, since time is a very important factor for transport systems. The collection process is carried out through specialized devices that work with transportation networks and perform multiple functions. Among these devices are the Automatic Vehicle Identifiers associated with them, as well as the Global Positioning System (GPS) based automatic positioning devices, cameras, sensors, and others (Sepideh, et.al, 2020). These devices record data for transportation systems such as traffic movements, travel speed and time, monitoring, vehicle location and weight, various delays, and others. All this information is collected in the systems' private servers in large quantities for analysis and so on) Julio, et.al, 2016).

Data transmission: Since time is the important factor in intelligent transport systems because of the high mobility and mobility of the nodes in it, therefore it requires efficiency in organizing communication mechanisms and achieving good connectivity through good coverage for the purpose of rapid and real-time information communication (Sepideh, et.al, 2020). This strategy of data transfer relies on transferring the data collected in the data collection stage from the systems and transferring it to the TMC and there it is analyzed and then the data is transferred from the TMC to the systems. Among these transferred data are advertisement messages and travel cases, either via the Internet or through the units on the transportation vehicles. Other communication methods can be used such as ad hoc short-range communications (DSRC) using radio and continuous medium and long-range air interfaces (CAILM) using cellular communication and infrared links) Julio, et.al, 2016).

Data Analysis: This process takes place in TMC after collecting data in the collection phase and transmitting it in the data transmission and receiving phase by TMC. Data processing goes through stages such as error correction, data synthesis and cleaning, adaptive logical analysis. Errors and differences are identified through specialized programs that clean, correct, modify and analyze them, then compile and send them back to the systems. This collected data can be used to predict traffic scenarios and road problems in order to provide better services to travelers (Julio, et.al, 2016).

Figure 2.2 Strategic planning for ITS implementation

2.2.2 The Benefits of an Intelligent Transport System

Transportation is one of the most important requirements of daily life, as it provides speed in movement, facilitates many life matters, and fulfills various needs (Dan Lin, et.al, 2016). Intelligent transportation systems play a vital role in managing transportation in a safe and coordinated manner in several aspects (Sepideh, et.al, 2020). Networks dedicated to vehicles do not contain a fixed infrastructure, as the nodes in them move quickly, variable and randomly. Therefore, the process of exchanging information and communications in terms of finding the shortest path and finding the next node is difficult in this type of network due to the change in its dynamic structure. Therefore, the use of a system such as Intelligent Transportation Systems is an important factor in trying to manage these networks in a better and more efficient manner as shown in the figure 2.4 (Taoufik and Sofian, 2020).

The technologies used in intelligent transportation systems vary in terms of simple management such as vehicle movement, different signals when controlling traffic, managing containers, transmitting messages of various types and purposes, automatic recognition of number plates, managing speed cameras, monitoring applications of different systems such as Security CCTV systems (closed circuit television), systems for detecting disasters, road accidents and parked vehicles, to advanced application systems such as security CCTV, automatic prediction system for accidents or disasters and so on (Oussama, et.al, 2020).

The advantages and benefits of an Intelligent Transportation System (ITS) can be summarized as the following:

- **Saving time**: which is an important factor in transportation systems by reducing the number of unwanted stops.
- **Safety**: controlling the vehicle's speed and alerting drivers of the road.
- **Entertainment**: improving and providing comfort in travel.
- **Management**: through the process of managing data and traffic.
- **Environmental**: reducing the impact on various types of environments.

Figure 2.3 Vehicular Ad hoc Network

2.3 Communication Systems of VANET

After the network is set up in VANET and connected to each other through on-board communication modules, there are standards for communications and radio access in the vehicular environment set by IEEE (Taoufik and Sofian, 2020).

- The IEEE P1609 WAVE standard addresses layers from the application layer up to the network layer
- The DSRC standard addresses the management of the physical and data link layers.

Figure 2.4 shows the different layers that the standards deal with. The very low latency compared to other network architectures is an essential advantage of DSRC wireless technology (Michael, Travis, 2020).

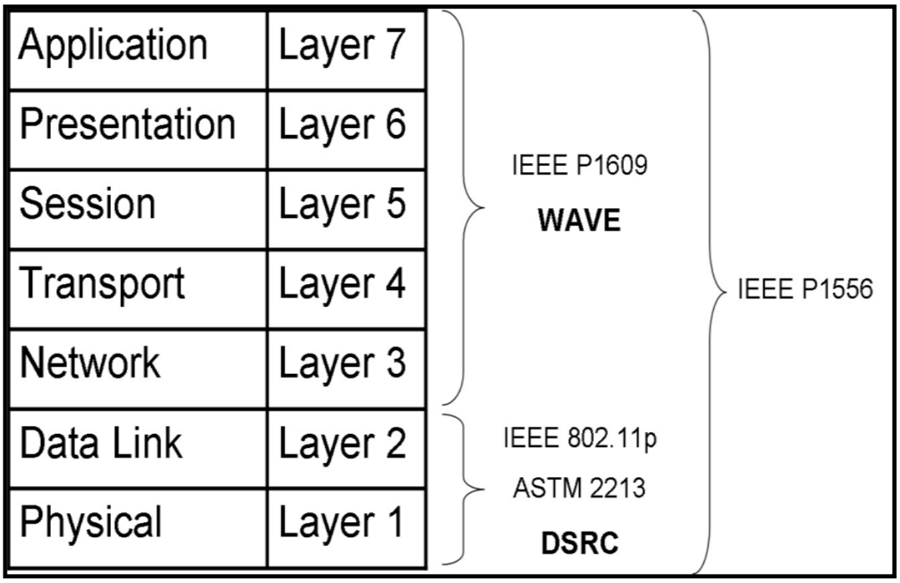


Figure 2.4 Breakdown of standards and network layers for the vehicular

2.3.1 DSRC with VANET

DSRC is used for short range wireless communications. It is somewhat similar to WiFi, however, what distinguishes WiFi is that LANs use WiFi (Dan Lin, et.al, 2016). DSRC is used in vehicle networks to communicate and exchange information between vehicles and between vehicle and infrastructure (roadside units) thus ensuring a high-speed wireless connection that simulates network speed and requirements and is highly secure (Sabih, et.al, 2013).

The basic features of DSRC are:

- The latency (delayed opening and closing of the connection) is less than 0.02 seconds.
- The radio interference is very low and effective, as it has a short distance of about 1000 meters.
- Weather conditions do not affect its work and effectiveness in the network.
- It operates on the 5.9GHz band where it is allocated to 75MHz.
- DSRC was created specifically for safety purposes such as warning drivers of collisions, accidents and disasters. The basis for DSRC wireless technology.

2.3.2 Architectures of VANET

Due to the rapid and changing movement between the elements of the vehicle network, it does not have a specific and fixed link structure, as its architecture depends on the type of link between the network nodes as shown in the figure 2.5 (Taoufik and Sofian, 2020). The main purpose of communication is to exchange information and share data between vehicles and the environment, for example, another vehicle or infrastructure, etc. Therefore, this can be distinguished through three types of communication:

2.3.2.1 Vehicle-to-vehicle communications (V2V)

This strategy of communication is vehicle-to-vehicle, vehicle-to-vehicle, or vice versa; where vehicles exchange information about the road with each other, such as location, speed, direction, and stability between vehicles, or with regard to road accidents (Tanuja, et.al, 2015).

DSRC is used as a communication model with a range of 300 meters through which the vehicle can send and receive data with other vehicles. Vehicle communications can be used to reduce traffic jams in order to prevent accidents or avoid them before approaching them. VANET is considered in this type of communication as a special case of MANET (Faruk, et.al, 2020).

2.3.2.2 Vehicle-to-Infrastructure Communications (V2I)

This strategy involves connecting the vehicle to the road through roadside units (RSUs) that are deployed in an orderly manner along the road. It includes the exchange of data such as traffic lights, road conditions, routers, Internet connectivity, and so on (Tanuja, et.al, 2015).

DSRC is used as a communication model where it has a range of 1000 meters through which the vehicle can send and receive data with roadside units. This type of communication can be utilized to provide drivers with valid, reliable and useful information and to collect data about vehicles and other infrastructure for analysis or forecasting purposes (Oussama, et.al, 2020).

2.3.2.3 Hybrid Communications (V2X)

The strategy is the integration of the (V2V) and (V2I) architectures that include Hybrid Communication. Nodes communicate directly (V2V) within hybrid networks. At the same time, vehicle communication is conducted through (V2I) in the areas served by the RSUs. This strategy helps to improve connectivity and increase network coverage without excessively increasing implementation costs. This type includes a mixture of several communications that the vehicle can use to perform various purposes, such as entertainment, safety, knowledge of road maps, and so on (Tanuja, et.al, 2015).

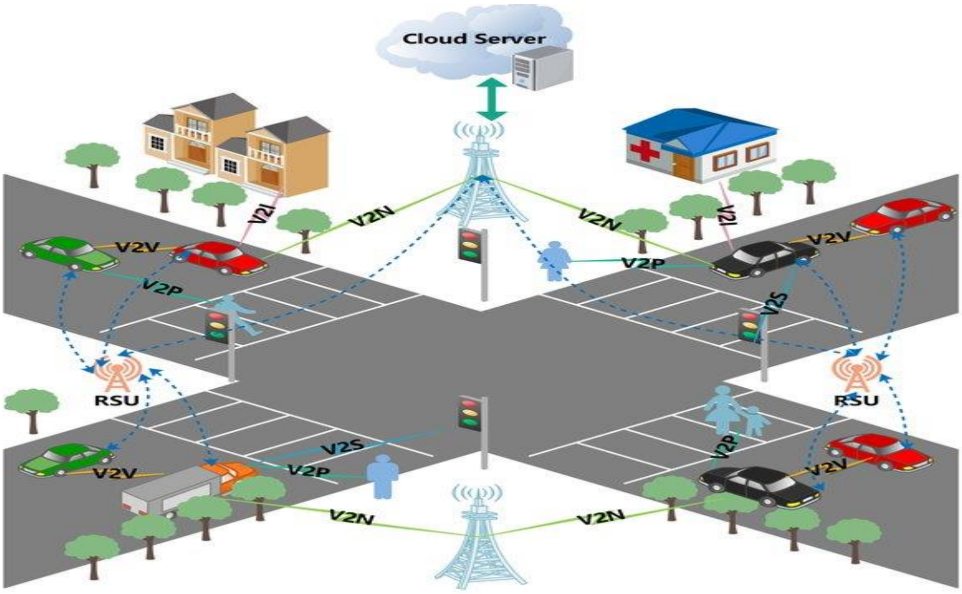


Figure 2.5 VANET Architecture

2.4 VANET characteristics, challenges and Applications

2.4.1 Characteristics of VANET

- **High predictive navigation:**
  In VANET, nodes move quickly and randomly, unlike other types of ad hoc networks, which makes it difficult to predict the movement and position of nodes, as the node has a high mobility at a speed of up to 120 km / h, and sometimes it can reach more than 200 km / h as a relative speed (Taoufik and Sofian, 2020).

- **Dynamic Network Topology:**
  With regard to the high traffic and the different and random speed of the node, its location changes during the roads frequently, and this leads to a frequent change of the VANET topology as well. This leads to instability of the connection, which causes communication and transmission failures and negatively affects the reliability and operation of the network (Taoufik and Sofian, 2020).

- **Unlimited network size and density:**
  VANET can be in one city or country or extend to a group of cities or countries together, and the density of node distribution within it varies according to the type of environment in which it is located, such as urban environments, highway environments, and others (Tanuja, et.al, 2015).

- **Use of wireless communications:**
  VANET was designed to use the wireless environment in communication, as it has all the advantages of a wireless environment in terms of exchanging and collecting information in easier, smoother and faster ways (Mustafa, et.al, 2020).

- **Provide enough energy:**
  VANET nodes do not have a power supply problem like MANETs, since these nodes are equipped with a long-lived power supply that can supply the OBU permanently. This enables VANET to be used for challenging technologies such as RSA (Rivest-Shamir-Adleman) or ECDSA (Elliptic Curve Digital Signature Algorithm) and so on (Judith, et.al, 2022).

- **High computational ability:**
  Nodes in VANET communication equipped with a different high number of resources, such as CPUs, memory, and GPS. Vehicle communication increases the network's processing capacity (Taoufik and Sofian, 2020).

2.4.2 Challenges of VANET

With all the advantages that were mentioned in the previous section, VANET networks are exposed to several challenges that negatively affect the network's work. The most important of these challenges are the following:

- **Dynamic Network Structure:**
  Network structuring problems occur because its continuous topology changes over time as a result of the rapid and variable vehicular movement across the roads (Taoufik and Sofian, 2020). Therefore, it requires a correct methodology to maintain the communication process between vehicles and increase the strength of the link between vehicles and roadside units to increase connectivity and coverage. Predicting the location, movement and

control of the node is difficult due to the rapid and variable movement of vehicles (Mustafa, et.al, 2020).

- **A dynamically changing network connection:**
  In VANET, nodes are fast-moving, active, and subject to a set of "on/off" connections along their path. Radio waves are also exposed to interference in some cases, as well as in cases of network congestion and problems in communication channels, all of which led to weakness and failure in communication. Therefore, there is always a need to provide protocols that help reduce "link failures" and increase "coverage and connectivity" of the network to maintain its quality and provide better services (Judith, et.al, 2022).

- **Real time constraint:**
  Time is considered one of the most important factors in VANET communications to deliver important messages, which must be instantaneous, such as accident messages for vehicles or roads. Therefore, several methods must be identified to deliver these messages within the shortest possible period of time commensurate with the fast and frequently changing VANET environment (Mustafa, et.al, 2020).

- **Quality of Services (QoS):**
  Quality of service is a standard when creating any end-to-end connection that must meet its requirements. The requirements of each application must thus be met according to its standards to achieve the best service provided, and this requires the existence of several mechanisms to meet the quality-of-service requirements for each application (Mustafa, et.al, 2020). For example, when there is a problem in not reaching the vehicle due to the location of the vehicle or its changing speed and the factors surrounding it, and so on, this requires the quality of another steering mechanism to work with it (Judith, et.al, 2022).

- **Data security and privacy issues:**
  Vehicles exchange several information of their own while communicating on the road for several purposes, and this may expose the vehicle to record its personal information, activities, and indicate its path and individual actions, and this may expose vehicles sometimes to the leakage of information privacy, in addition to tampering with the vehicle's path or

signals during the road, and this poses several serious safety problems vehicle (Mustafa, et.al, 2020).

2.4.3 Applications of VANET

There are several applications available in VANET as shown in figure 2.6. The four main categories focused on Safety, Convenience, Commercial and Productivity.

- **Safety applications:** They are responsible for monitoring the safety of vehicles and the roads they pass by and their surroundings. It regulates traffic in real time and transmits safety messages such as alerts about collisions and road hazards (Taoufik and Sofian, 2020).
- **Convenience applications:** They are responsible for managing traffic in general for roads, including diversions, collecting electronic tolls, searching for parking lots, and continuous and effective prediction (Mustafa, et.al, 2020).
- **Commercial applications:** These are responsible for providing services to vehicles such as providing web access services, viewing digital maps, accessing photos and videos, and so on (Taoufik and Sofian, 2020).
- **Production applications:** which are responsible for fuel benefits, time consumption and anything related to the interests and benefits of different environments (Mustafa, et.al, 2020).

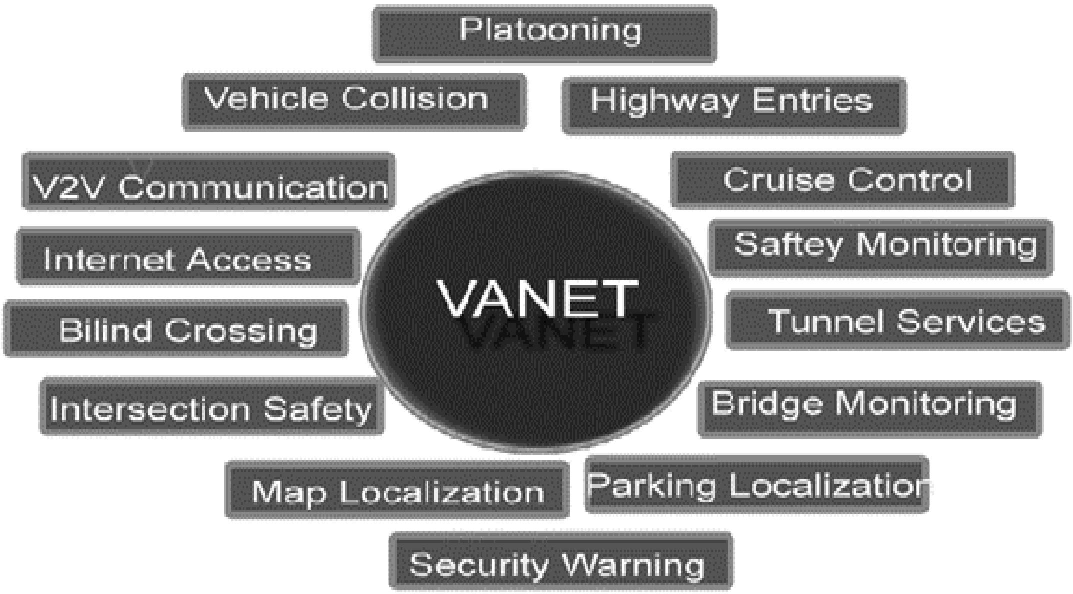


Figure 2.6 Application with VANET

2.5 Clustering Technique in VANET

Clustering is a mechanism for grouping some nodes that share certain characteristics into the same groups to form a hierarchical structure. There are multiple strategies for identifying aggregates in vehicle networks, including mobility-based, density-based, link-based, machine learning, fuzzy logic algorithms, and many others.

Each cluster consists of some potential node statuses, called cluster head and cluster member. The cluster head is the main axis of each cluster and its task is to form the cluster with the cluster members. It is responsible for all interactions within the cluster, managing intermediate access, and distributing resources to cluster members. Cluster members do not worry about their communication with each other and with others. They only have to share and exchange information with their block chief. Therefore, the most important task in clusters is to choose the head of the cluster, and there are several types of selection (Neglected metrics, Random metrics, Position metrics, Mobility metrics, Combined metrics, Destination Metrics).

There are two primary techniques for cluster formation: distributed and centralized techniques.

- Distributed Technique: This technique is used by many clustering mechanisms to create clusters. Each node in the network seeks local membership with the cluster header after collecting the required details from the neighborhood. Then this node sends a membership message to the cluster head to confirm its membership.

- Central technique: This technique is used in that the central node is responsible for the formation of clusters and membership of clusters. In vehicular networks, the Roadside Unit (RSU) is used as the central node for cluster creation and membership. The RSU spread beacon messages to nodes in the network, and each node sends a request for membership to the appropriate RSU. Thus, the cluster formation stage is completed centrally when the RSU collects membership applications. Finally, the RSU informs its members.

2.6 Data dissemination in VANET

Data dissemination is the exchange of data between transport parts, whether vehicles, roadside units, etc. through V2V or V2I strategies, etc. The dissemination of data within transport networks has benefits that enhance driving and movement and alert drivers to accidents in their areas through various applications (Alejandro, et.al, 2017).

Because of the nature of transport networks, which are characterized by high speed, structural change and periodic disintegration. Many approaches have been proposed for data dissemination methods in various strategies (Fei, et.al, 2012). The data dissemination approach is based on two main categories**:** Geocast-based or broadcast-based techniques. While the strategies are of the following types: Unicast, Multicast, or Broadcast, methods of dissemination of data in these networks are as follows: push, pull, and hybrid (Alejandro, et.al, 2017).

To accurately illustrate the different data dissemination approaches used in VANET, they can be categorized as follows (Sakshi and Paras, 2017):

- Vehicle to vehicle Forwarding
- Vehicle to Infrastructure Forwarding
- Cluster-Based Forwarding
- Peer-to-peer Forwarding
- Geocast-based Forwarding
- Opportunistic Forwarding

2.6.1 Vehicle to Vehicle Forwarding (V2V)

This communication is between vehicles and employs two strategies, flooding and relaying. In the process of flooding, data is collected from the area and published in the network, and this method is useful when applications are delayed in responding in distributed networks (Bidisha and Judhistir, 2023). When using the relay strategy, the transmission of information becomes the propagation across the network system by defining the relay hub (next hop). It is ideal for crowded networks because it is mainly concerned with reducing bottlenecks and is suitable for dense networks (Sakshi and Paras, 2017).

2.6.2 Vehicle to Infrastructure Forwarding (V2I)

This type is in contact between vehicles and roadside units or vice versa, and it depends on two main deployment modes, push and pull (Bidisha and Judhistir, 2023). Data is easily published from any vehicle or infrastructure through push-based deployment (i.e., pushing data and information to the network) and any other vehicle can receive this data and information via cloud-based data deployment (Sakshi and Paras, 2017).

2.6.3 Cluster-Based Forwarding

This type represents one of the best solutions for self-organization of the network, through the creation of clusters address vehicle network problems and challenges (Sakshi and Paras, 2017). For example, sending messages within one cluster with similar characteristics of distance, face, or roads, to reduce broadcast storms, for example, and improve the transmission rate. On this basis, nodes are grouped into groups and one or more nodes in their groups collect information and pass it on to the next group.

2.6.4 Geographical Forwarding

The topology of VANET is constantly changing, so VANET still has no defined methods. As part of the data dissemination, the geographical dissemination of the nearest destination center is used until it reaches the destination. Geo-casting is often used in some situations to transmit messages to a few geographic ranges of hubs (Sakshi and Paras, 2017).

2.6.5 Opportunistic Forwarding.

Data-driven design, where applications cannot be disrupted to exchange information in appropriate ways. This technology is used for storage and forwarding purposes (Sakshi and Paras, 2017). As a result, the roads are gradually being manufactured.

2.6.6 Peer-to-peer Forwarding

During peer-to-peer publishing, the source keeps the data in its own storage device and does not transfer it to the network until another center requests it. This is a proposal for an easy delay application (Sakshi and Paras, 2017).

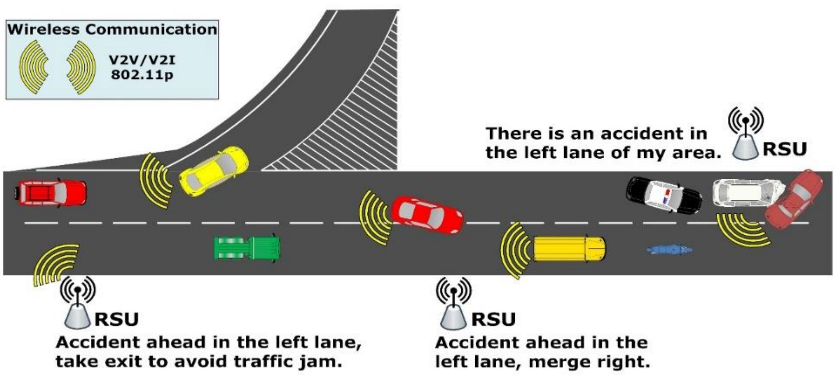


Figure 2.7 Data dissemination in VANET

2.7 Queuing Models

Queues are important and effective tools in building models and evaluating the performance of various systems, such as networks, communications, service processing and distribution centers, and others. Research from various engineering and mathematical disciplines is directed towards improving the use of waiting lists. It consists of three agency components: (B. Filipowicz et al., 2008).

- **Entities**: They represent the applicable part, such as clients or work packages in the service center. It is to be either a human or something in the system or the network waiting for processing or traffic and so on.
- **Queues**: They represent queues in a certain sequence in which entities enter and wait for traffic or processing.
- **Resources**: Resources: It provides the needs of the crisis to serve the entities in the waiting list.

The relationship between these three components is shown in the figure 2.8.

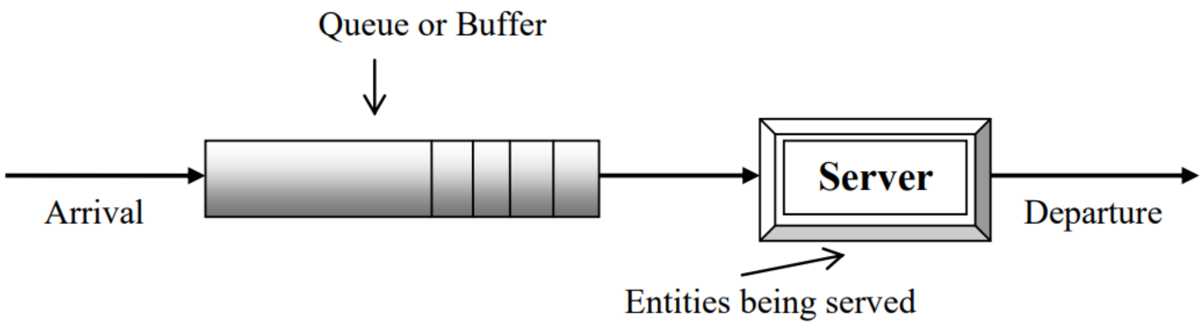


Figure 2.8 Basic queuing system components

Queues can be categorized to simple queue, or it can be chained to make a network of queues; thus, the departure from one queue enters to the next queue. Queuing network can be opened network or closed network. Figures 2.9 & 2.10 below shows the open network and the closed network representations.

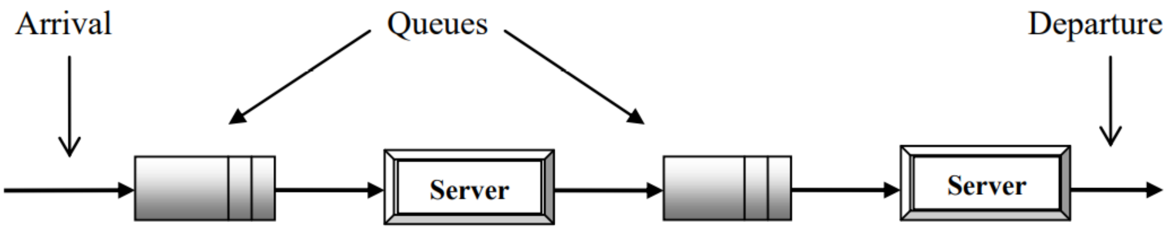


Figure 2.9 Opened queuing network

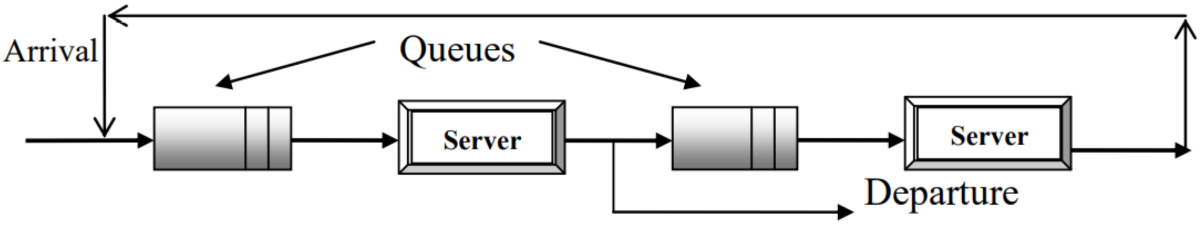


Figure 2.10 Closed queuing network

2.7.1 Basic Queuing System Concepts

Each queuing system is described by characters: A / B / C / X / Y / Z, these characters called Kendall's notation (A. Horv´ath, 2000), (Wenjing Xu, 2008) , (Andress Willig, 1999) , (Erasmus G B, 2006):

- **The first character (A)**: Specifies the arrival probability distribution (or the time between two successive arrivals). The following standard abbreviations are used:

  M = Exponential.

  D = Deterministic.

  Ek= Erlang type k.

  GI = General Independent.

- **The second character (B)**: Specifies the service probability distribution.

  M = Exponential.

  D = Deterministic.

  Ek= Erlang type k.

  GI = General Independent.

- **The third character (C)**: Specifies the number of parallel identical servers in the systems, denoted by 1 if there is only one server and by C if there are multiple servers.

- **The fourth character (X)**: Describes the queue length or the number of entities allowable to enter the system.

- **The fifth character (Y)**: Specifies the queue strategy. A queue strategy determines the discipline for ordering entities in a queue. It defines the order in which they are served and the way in which resources are divided between customers. Here are some of these strategies:
  - **First In First Out (FIFO)**: Entities are ordered according to their arrival times. The entity that has been waiting the longest is served first. This kind of queue is the most commonly used model because there are no differences between entities. It is a fair queuing strategy and low overhead. There is no infinite postponement in such a queue. But long entities may let the short entities wait for a long time.
  - **Last In First Out (LIFO)**: Sometimes, the entities are serviced in the reverse order of their entry so that the last entity join the queue serve first.
  - **Priority Queue**: Priorities are a measure of urgency or importance. Each entity is assigned a priority and the entities are sorted in the queue by their priorities. Low values represent high priorities.
  - **The shortest is served first**: So, the waiting time of short entity is small. But the latent danger is that the longer service time entities may be infinitely postponed.
  - **Random Service**: The entities in the queue are served in random order.

- **Round Robin**: Every entity gets a time slice. It will re-enter the queue, if it's service not completed.

- **The sixth character (Z)** specifies the calling source for entities asking for service. It is considered to be finite if these entities coming from finite population, or it can be infinite if the population they are coming from is infinite.

2.7.2 Performance Measurements

One approach to performance measurement is to obtain the data by observing the events and activities on an existing system. Performance modeling means representing the system by a model and manipulate the model to obtain information about its behavior and performance. The performance of the system can be estimated either directly or by characterizing the system workload mean response time, the total service time, the workflow, the numbers of completed or aborted service requests, the total waiting time, the queue length, the number of transactions completed per unit time, the ratio of blocked connection requests, and the rollback completion time are the most important performance measures (S. Sonntag, et.al, 2007). When analyzing a system with a single queue, the most common performance measures are obtained as follows (Wenjing Xu, 2008), (Andreas Willig, 1999), (Heikki Uljas, 2003):

- **Arrival distribution (λ): or** the average time between arrivals (Interarrival times = 1 λ). This distribution is considered the first statistical pointer that helped to determine the model type.
- **Service rate (μ)**: Number of departing entities per unit time. Service time is the average between departures (Inter departure time = 1 μ).
- **Server utilization (ρ)**: or (traffic intensity), describes the fraction of time that the server is busy, or the mean fraction of active servers, in the case of multiple servers.

$$\rho = \frac{\lambda}{\mu}$$

- **Queue length (L)**: The number of entities in the system including both the entities waiting for the service and the ones receiving it.

- **Waiting time (W)**: The total time that the Entities spend in the system waiting to be served.
- Pi: The probability of a given number of entities i in the system. In queuing theory, almost every queuing system can be represented by Kendall's notation and analyzed as the above performances measures.

2.7.3 Little's Formula

Little's formula is the most used formula in performance evaluations. It can be used with most queuing systems and applied to both single server systems and network of servers. It states:

$$N = \lambda * T$$

$$L = \lambda * W$$

$$Lq = \lambda * Wq$$

Where N is the average number of entities in the system, λ is the arrival rate to the system, T is the average time spent in the system, W is the average waiting time in whole system, Wq is the average waiting time in the queue, L is the average number of entities in the system, and Lq is the average number of entities in the queue (Heikki Uljas, 2003), (Philippe nain, 2004), (Andreas Willig, 1999.

CHAPTER THREE

The Proposed System

3 CHAPTER THREE
The Proposed System

3.1 Introduction

This chapter explains the simulation steps of implementing the model suggested for optimizing data transmission rate to improve the intelligent transport systems. The first part of the suggested model in this thesis proposes distributing the roadside units on a regular basis ensures that the vehicle remains connected along the road with one of the side units to ensure connectivity and communication and reduce link failure. The second part of the suggested model deals with different types of messages and gives different priorities to messages before sending them. Messages are transmitted based on their priority to avoid losing emergency messages.

Simulation is a very important tool due to the cost and difficulties of real application in VANET environments scenarios, therefore Netlogo 6.3.0 (as an agent-based modeling approach) has been used in implementing the simulation scenarios.

3.2 The Proposed System Framework

Despite the different approaches with the development of VANET, many challenges remain as still open problems. Among these problems are the data dissemination and data transmission rate process that faces difficulties due to the changing density of the network, high traffic of vehicles, the absence or adequacy of infrastructure, the extent of the geographical areas that will be covered, the number of messages sent through the network, and most importantly the loss of important and urgent messages due to the momentum of messages and their mixing with ordinary messages which are less important and may not be useful. The proposed approach in this study aims to allow the transmission of information between all vehicles and prevent the network from flooding it with redundant information or unnecessary information (in broadcasting) by filtering messages and giving important messages degrees of priority, thus improving the data transfer rate between vehicles.

The main stages of the proposed system are represented by: designing and building scenarios with different parameters (number of nodes, transmission range, data dissemination type, message priority type and acceleration deceleration of vehicles) using a networks simulator Netlogo. Figure 3.1 refers to the proposed system.

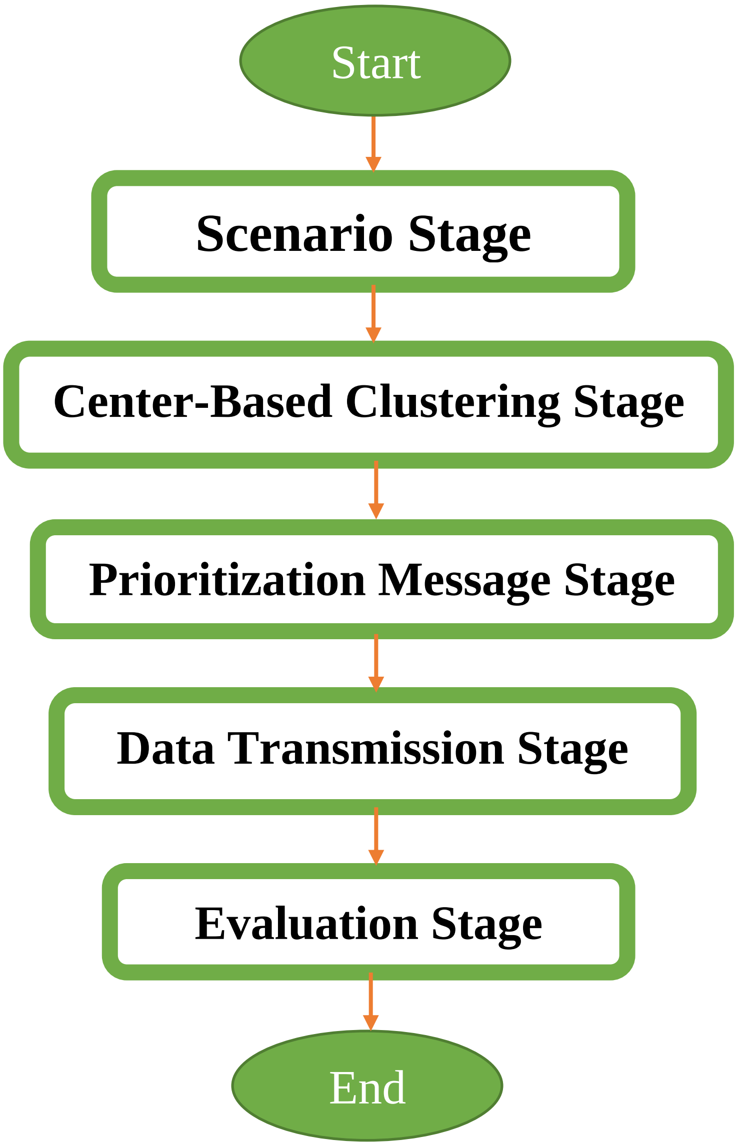


Figure 3.1 a block diagram for research framework stages

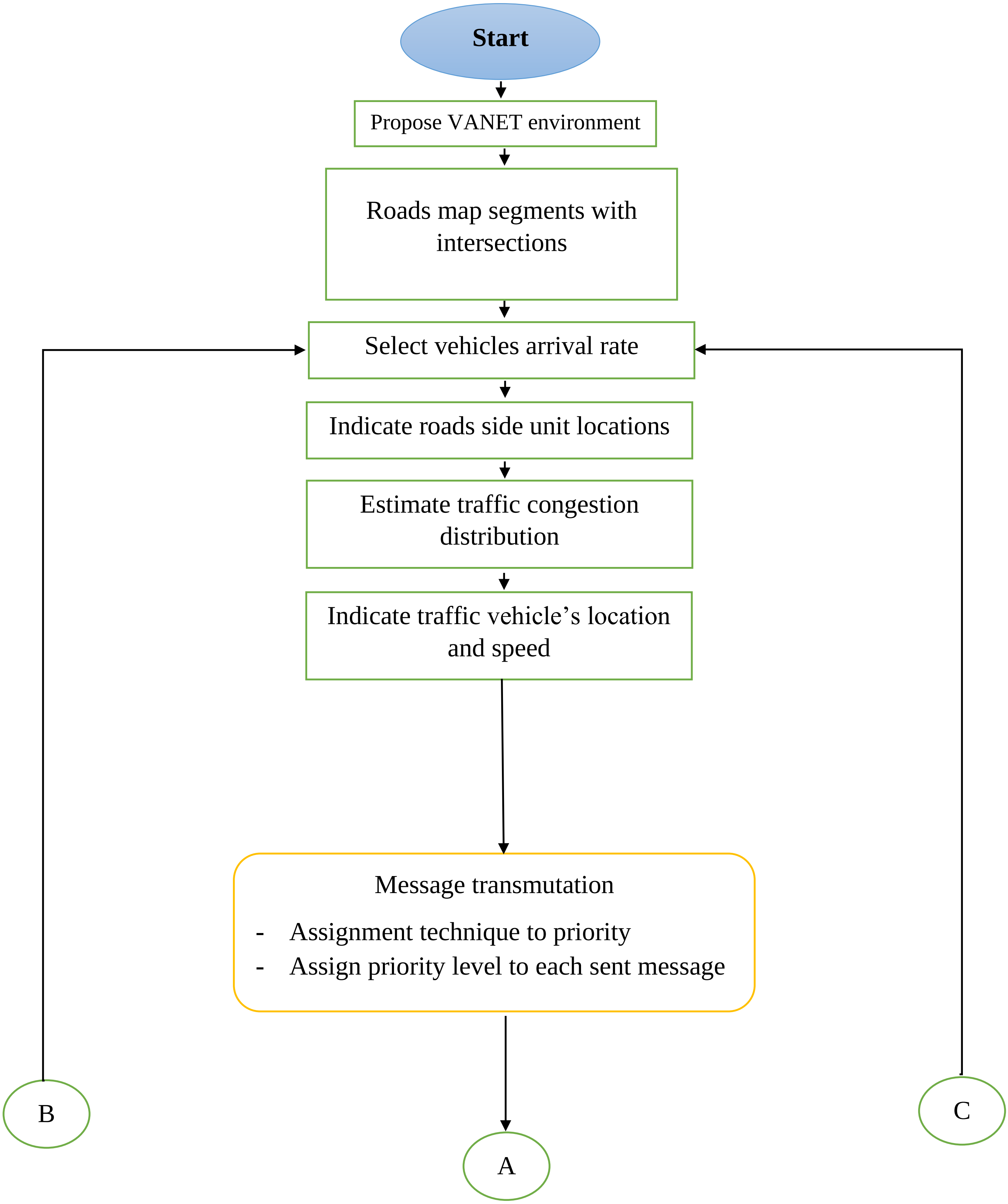
3.3 Methodology

The following section represents the main steps of the proposed system in more details followed in these experiments.

The steps for building, implementing, and evaluating the proposed system are detailed in the general flow chart shown in Figure 3.2.

This flow chart illustrates the instruction steps for implementing all hypothetical scenarios where the action is represented as a process approach in each step.

According to the applicable model, actions that differ according to the applicable model represent the first group: (building and implementing the road, determining vehicle restrictions, and establishing it inside the road). At the same time, the actions that share all the proposed methods represent the second group. Each group of actions will be explained in the next section.


Start
Propose VANET environment
Roads map segments with intersections
Select vehicles arrival rate
Indicate roads side unit locations
Estimate traffic congestion distribution
Indicate traffic vehicle's location and speed
Message transmutation
- Assignment technique to priority
- Assign priority level to each sent message
B
A
C

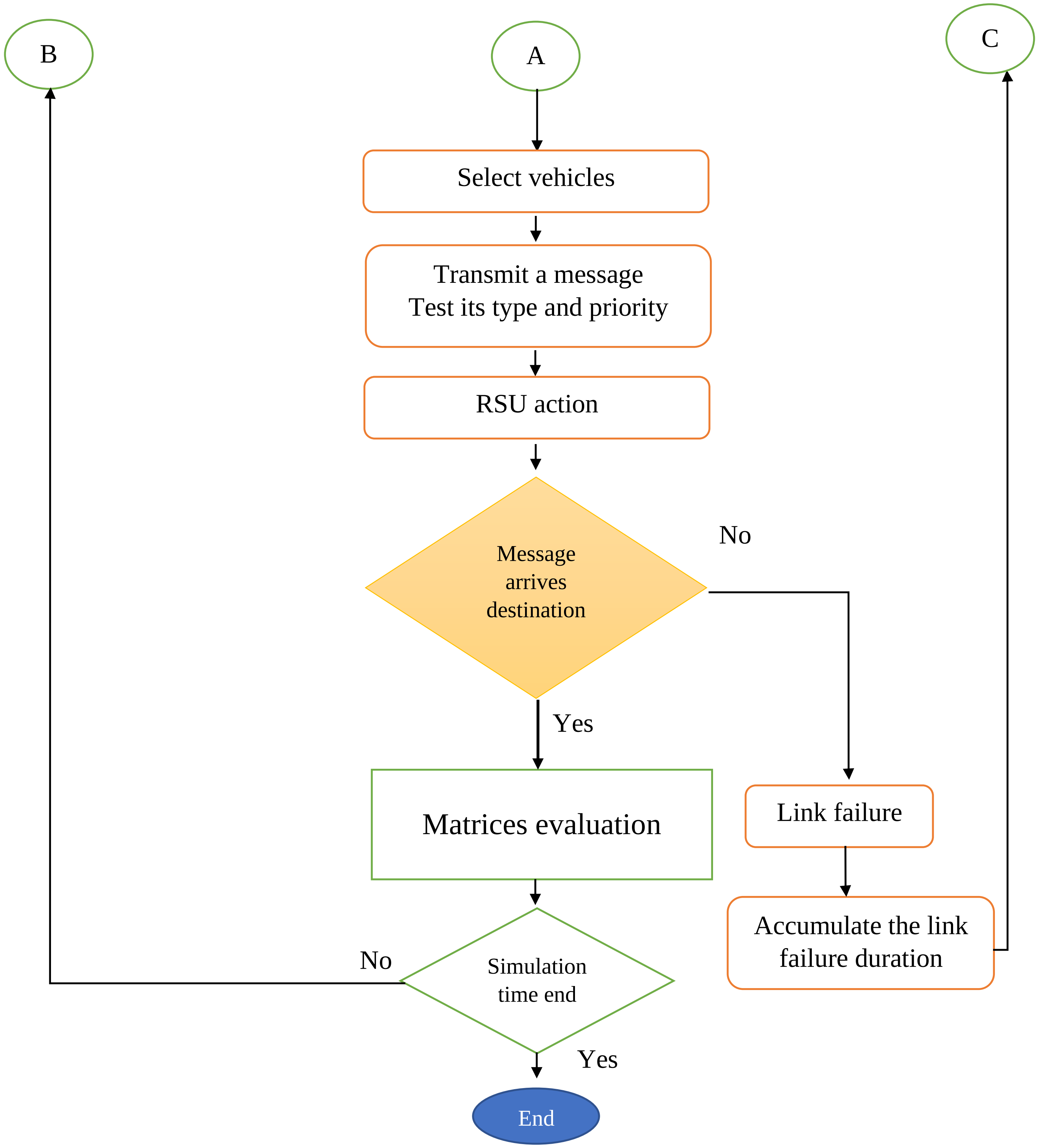


Figure 3.2 General proposed system flow chart

3.4 Model building

In this stage, many steps are performed to prepare and set the requirements for the VANET using Netlogo 6.3.0 simulation environment as an agent-based modeling approach.

Each template has several elements that are tools to apply and display simulated results. This element includes: (buttons, sliders, screens, and charts). The buttons include an action code such as the Setup button or the Start button or send message button (To send different types of messages with setting the priority for each message). The slides include the input values for the parameters that are called during processing. Sliders of acceleration and deceleration have been set to control the vehicle's speed. It also contains the output, whose function is to display and print the output after executing it in the code. The plots display the relationship between parameters during the simulation process. Finally, various switches are used to modify a variable easily without the need to re-encode the process. They are a visual representation of a given process (true/false).

All these tools showing in figure 3.3 aim to design and create models similar to the actual roads and simulate them in many scenarios to display and compare the effects between them.

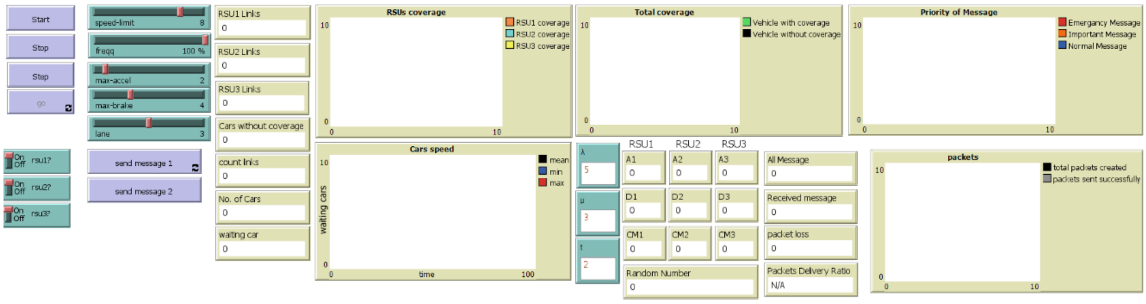


Figure 3.3 Snapshot of the different tools used in models

3.4.1 Setup Lanes Road Model

The environment setup starts with creating a suggested road segment. The road segment is designed and divided into lanes using Netlogo 6.3.0 as an agent-based modeling approach. The RSUs are also created and located along the road segment.

vehicles are generated on the road as soon as simulation begins and at various locations and speeds, in the flow style with a set density of flow, where this model entirely controls the world. The flow of vehicles and distances between vehicles is assessed.

Vehicle activities are investigated to create links between vehicles and links on the roadside to RSU. In each simulation attempt, the number of vehicles is entered. To monitor vehicle speed, "acceleration and declination" sliders have been applied and the report of the speed of cars is previewed through the plot.

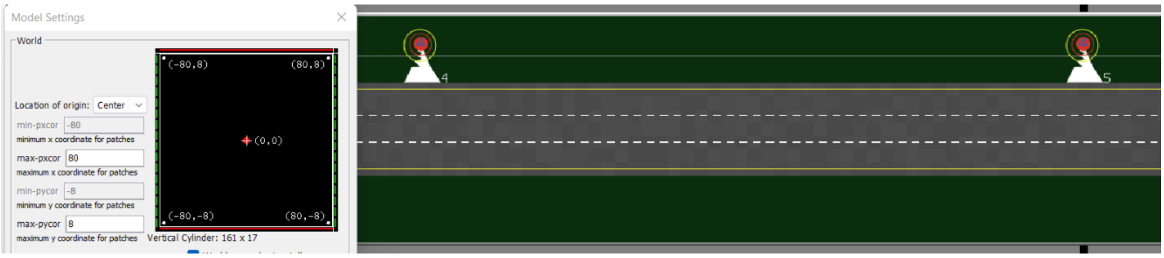


Figure 3.4 lanes road model

- **Assumption**: figure 3.4 explains the scales of the dimensions of the environment which described as follows between the upper bound of the x-axis (80), and the lower bound (-80), and the y-axis, upper bound was (8), and the lower bound (-8). The vehicle is heading in the direction of 90 degrees. The road was divided into the vector that consisting of the following numbers.

  Vector = {-8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8}

  Some of the vector numbers will represent the road lanes of the vehicles as a set RL, thus ensuring that the vehicle does not leave the specified lanes.

  RL = {-2, 0, 2}

  While the numbers represent each of the roadside planning in a yellow lane as a set YL.

  YL= {3, -3}

  The separations between the three lanes with a dashed white line in set DL.

  DL= {1, -1}

Finally, the number {0} will represent the middle of the map, on which the roadside unit will be constructed.

Figure 3.5 Explains the algorithm of designing and building the road map.

It should be noted that when creating the road in NetLogo, we will be dealing with patches where the patch represents the X and Y coordinates of a small portion of the environment. Therefore, consider the world as a collection of patches, and to make changes to patches, this must be asked from them. After the road design and construction process.

settings for road map model

Step 1: - Adjust horizontally and vertically the interface screen sizes to view a road map segment.

```
Ask to set the world.
[Set origin location ⟶ center
Set (max-pxcor, min-pxcor ) ⟶ (80 ,- 80) // Pxcor1 is x-coordinate for patches
Set (max-pycor, min-pycor ) ⟶ (8 ,- 8) // Pycor1 is y-coordinate for patches
```

Step 2: - Distinguish the segment that will reflect the road from the assigned part of Step 1 by making its color different from that of the entire world.

```
Ask patches [ set pcolor ⟶ 61]          //color is 61 in color map with Netlogo
Ask patches with [ pycor <= [ n -> (2 / 2) * (number-of-lanes - (n * 2) - 1) ] * (2 / 2 )]
[ set pcolor ⟶ grey]                   // the road itself is grey
Set lanes ⟶ [-2, 0, 2]                 // list patches represent of number-of-lanes items
Set y ⟶ [ L-lanes] - 1                 // Begin under the "last" lane
while [ y <= F-lanes + 1]
[ if [not member? Y ⟶ lanes]
[ if [ y = (F-lanes) + 1 or y = (L-lanes) – 1]          //create lines that do not belong to the lane
   [ create-line y yellow 0 ]  called ⟶Function1   // Yellow on the lane sides
Else [ create-line y white 0.5 ]  called ⟶Function1   // lanes with a dashed white
   ]
Set y ⟶ y + 1                          // one patch upper is move
 ]
```

Function1: - draw-line [y line-color dis] // function to draw lines on the road, dis = distance.

```
[ Ask patch with [pxcor = min-pxcor - 0.5 and pycor = y]
 Set pen[color] ⟶ color-of-line
 Repeat width-of-word
 [ pen-up ⟶ F-ward dis              // get a constant line with a zero dis.
 pen-down ⟶F-ward (1 - dis)         // get a dotted line with a dis larger than zero.
 ]  ]
```

Step 3: - create one RSU (roadside unit) on the side of the road.

```
create-bridges 1 [set shape⟶"bridge", set color ⟶ yellow, set ycor⟶0, set size 2.5,
 set xcor⟶ 0]               // Repeat the process to create more than one roadside unit
```

Figure 3.5 settings for road map model

3.4.2 Create and Move the Vehicles

In the simulated environment, create the vehicle with properties of (shape, size, color, the direction of movement, and manner of generating it on the road). The number of cars created is continuous over time as long as the simulation is effective.

- **Assumption**: In the beginning, the object will be made to take the shape of the vehicle, then the lane number will be determined from the list of lanes RL = {-2, 0, 2}, and this will be random. Then the speed of the car is determined based on its entry into the simulation. In the event that there is another car in front of it or any other object that slows down its movement, or increases in the absence of anything.

Settings for Create and Move the vehicles on road map model

Step 1: - set the name of turtles to cars and shape to car shape, and cars are created in the road.
Breed [cars ⟶ car] //breed: is function to change the turtles name.
set-default-shape turtles ⟶ "car" // turtles shape change to car.
set-default-color turtles ⟶ 125 // color is 125 in color map with Netlogo for cars.

Step 2: - Create cars at the start of the road and scatter them over three lanes.
create- cars ⟶ 1.
Ask car [set heading ⟶ 90] // determine the direction of movement for car.
Ask car [set xcor ⟶ (- world-width) set ycor ⟶ one-of lanes] // lanes = [-2, 0, 2]

Step 3: - Size and speed are customized for any car.
Ask car [set size ⟶ 1.5
set speed ⟶ (0.5 + random-float 0.5)],
If [xcor = 6] [set speed-limit ⟶ 1.2]
Else If [xcor = 4] [set speed-limit ⟶ 1.1]
Else [set speed-limit ⟶ 1]

Step 4: - Assigning and displaying a special identification for every car.
Ask car [set label ⟶ who] // Who = (id) for any car Begins with (0) and ends with (number-of- cars - 1)

Step 5: - Ask vehicles if any? Other- vehicles-here [forward 1] // cars are separate in the road
If [speed > limit-speed] [set speed ⟶ limit-speed]

Figure 3.6 Settings for Create and Move the vehicles on road map model

Figure 3.6 explains the steps for creating cars and the process of generating them on a road map.

Notes:

- To avoid the movement of vehicles on top of each other, Making the vehicle move forward when another vehicle approaches it.
- Every new vehicle entering the road will be given a unique identifier represented as (who) that starts with the number {0} and increases by {1} for each new vehicle.

$$Who_{\text{new vehicle}} = Who_{\text{old vehicle + 1}}$$

- When creating vehicles, they will be dealing with turtles. As is the case with patches, they can also ask turtles to change their properties or take a specific action.To facilitate the process of dealing with vehicles, especially in cases of sending and receiving messages.

3.4.3 Controlling the Movement of Vehicles

As regards the movement of vehicles on the lanes, two slides are used: acceleration and deceleration. The vehicle increases its speed according to acceleration when no vehicle ahead. While decreases its speed equivalent to deceleration if there is no vehicle ahead as shown in figure 3.7.

$$Vehicle_{\text{speed-up}} = vehicle_{\text{speed}} + Acceleration$$

$$Vehicle_{\text{speed-down}} = vehicle_{\text{speed}} - Deceleration$$

Settings of controlling the movement of vehicles

Step 1: -assign the initial speed of vehicles.
set speed 0.5 + random-float 0.5
Step 2: - high and low limits for speed are determined.
set speed-limit ⟶ one of [1,1.1,1.2]
set speed-min ⟶ 0 //depend on number of lanes.
Step 4: - controlling the movement of vehicles.
Set car-ahead ⟶ one-of cars-on patch-ahead 1 //to represent the car in front of it.
If [car-ahead = nobody]
[speed-up-car] // Increase the vehicle speed.
Else [slow-down-car car-ahead] // speed down to less than the car's speed in front.
// Do not slow down to minimum speed or speed above maximum
If [speed < min-speed] [set speed ⟶ min-speed]
If [speed > limit-speed] [set speed ⟶ limit-speed]
Step 5: - moving the vehicles on the road.
Ask cars [forward ⟶ speed].

Figure 3.7 Settings of controlling the movement of vehicles

3.5 Proposed Clustering Approach

Working with the concept of clustering is important for ad hoc network (VANET clustering), as each group organizes different moving vehicles together and in a non-overlapping manner. As shown in figure 3.8 in each group belongs to a roadside unit, and within its scope, the number and range of one group is determined. There are multiple strategies for identifying aggregates in vehicle networks, including mobility-based, density-based, link-based, machine learning, fuzzy logic algorithms, and many others.

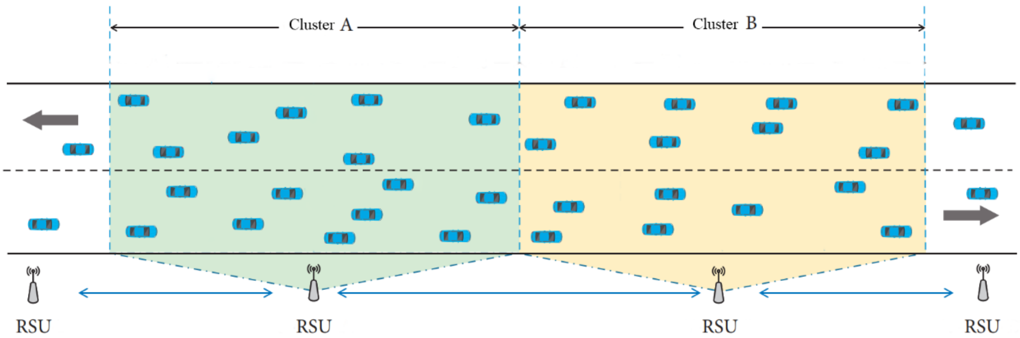


Figure 3.8 Communication Layout

The set of the collected vehicles in one separated group is called a cluster. Generally, there are two strategies to cluster formation: distributed (Ad hoc) and centralized. In this proposed system, the center-based clustering strategy is proposed to manage and control the clustering process with the assistance of the RSUs. The proposed clustering mechanism has been applied to RSU as a (spatial cluster) where each RSU (Cluster Head) is responsible for covering its own area, and any vehicle within a particular RSU area connects to it represent as Cluster Member. RSUs can conducts the cluster formation step. Firstly, each vehicle will send the message to its adjacent RSU, this message contains the position of this vehicle and its ID (who). Each cluster will be collected by the administrator in the RSU according to the coverage radius of each vehicle. The non-overlapped style is selected in all this thesis simulation experiments.

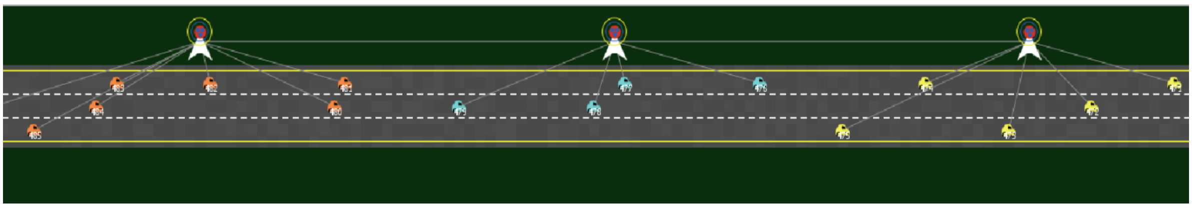


Figure 3.9 clustering vehicles in simulation

Algorithm 3.1 for establishing links in a proposed cluster approach

Initial: number of vechles, RSU.

Begin

Step 1: To determine whether to establish communication with another vehicle or with an RSU.
ask cars [if [other = bridge] //other: which may be another vehicle or RSU.
[set range1 ⟶ range-RSU]
Else [set range1 ⟶ range-car]

Step 2: Start creating links if the terms of range contact are met
If [distance with other <= range1]
[create-link-with ⟶ other, set link-end ⟶ 1 put other]

Step 3: Remove links if they out of range contact are met
Ask cars [If [distance with other > range1]
[if [member? Other ⟶ [link-end]]
[set link-end ⟶ remove other, set link-with other ⟶ [die]]]]

Begin

Algorithm 3.1 illustrates how establishing links in the Clustering method and as the following point:

- RSU broadcast many of messages periodically with RSU ID (who) or its location to each vehicle continuously in their scope.
- when any vehicle enters in the communication range of RSU it receives the RSU ID (who) or its location.
- In the case that the vehicle does not obtain the RSU ID (who) or its location, it must request it through the ICMP packet.
- The vehicle is now within range of the RSU (Cluster).
- When the vehicle has information that it wants to send to the network, it sends it to the roadside unit, specifying the type and importance of the message.
- In the case of the source not obtaining acknowledgment of receive the message from the roadside unit, it will resend it.
- The roadside unit receives, filters and sends the message according to the details attached to the message, and sending it to the destination.
- In the case of not obtaining acknowledgment of receive the message from the destination, the roadside unit will re-transmit it to the destination.

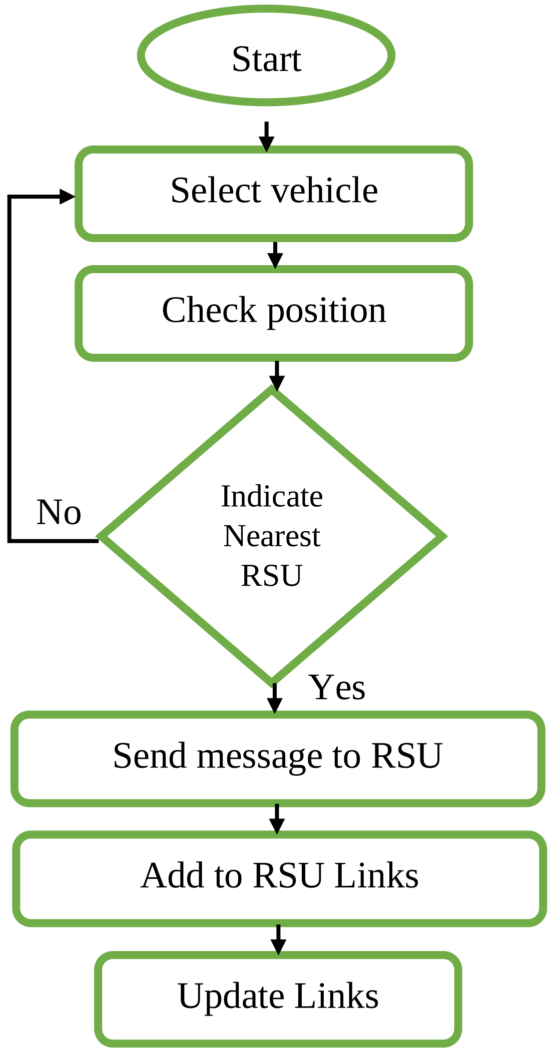


Figure 3.10 Flow chart for proposed cluster approach

The evaluation process of the proposed algorithm for clustering is based on performance metrics related to the coverage of RSU. Therefore, number of vehicles, number of arrival vehicles to a cluster area and number of departed vehicles from a cluster area at time as indicate the efficiency of the clustering algorithm.

- **Assumptions**

  CH = Cluster Head CM = Cluster Member

  CH Selection ⟶ RUS

CHi Position = (Xi, Yi)

Cluster radios = Coverage area of RSU ⟶ 1000m

Cluster diameter = 2 Coverage area of RSU ⟶ 2000m

- **Model:**

CMs (t) is Variable = No. of vehicles (N) at time (t-1) + No. of arrival vehicles (A) to a cluster area at time (Δt)- No. of departed vehicles (D) from a cluster area at time (Δt)

$$CMs(t) = N(t-1) + A(\Delta t) - D(\Delta t)$$ ***Equation 3.1 calculation Cluster Member***

$$A(\Delta t) = \lambda * (\Delta t)$$ ***Equation 3.2 calculation No. of arrival vehicles***

$$D(\Delta t) = \mu * (\Delta t)$$ ***Equation 3.3 calculation No. of departed vehicles***

Where:

λ = arrival rate

μ = departure rate

Δt = very short time period.

3.6 Proposed Data Transmission Approach

Messages are exchanged in vehicle networks for various purposes, such as information about the road or about vehicles, such as determining their speed or destination road. A message may be important and emergency information related to road accidents and problems.

Messages differ according to their importance, and the vehicular network deals with all messages at the same way in sending, and this represents a problem for vehicle networks, because emergency messages related to road disasters must be sent before sending the rest of the messages that are sometimes considered unnecessary. It also suffers from another problem, which is the time being in vehicle networks, the vehicle moves at an instantaneous speed, it must be alerted to disasters on the road at the same moment before they occur in the accident, which often causes the loss of the lives of drivers and passengers. In order to solve these problems, the proposed approach in this thesis offers multiple priorities to messages.

The messages that are transmitted within the vehicular networks vary in importance and require fast processing because the vehicles move quickly and the network topology is frequently changes. In the proposed system, these messages can be classified according to the following assumptions:

- A message is classified as a normal message if it related general or entertainment information.
- A message is classified as an important message if it concerns alert or indication about congestion, road problems, emergency vehicles, etc.
- A message is classified as an urgent (emergency) message if it is considering the vehicle collisions, fires, dangerous and fatal accidents, ambulances, etc.

The packet format is used in a transmitting unit of the VANET. It consists of a group of parts (sequence, type, source address, destination address, time stamp, data) as shown in the figure 3.11 (Yashar, et.al, 2021).

0-8 bit	9-15 bit	16-37 bit	38-59 bit	60-79 bit	variable
sequence	type	source ID	destination ID	time stamp	data

Figure 3.11 Normal packet format

The proposed approach is based on the priority of messages. Assigning a certain priority to each message can be indicated by exploiting using the first (2 bits) to specify the type of the message priority. Dealing with the packet format is performed according to that recorded priority.

If the priority message = 00 ⟶ [Normal message]

If the priority message = 01 or 10 ⟶ [Important message]

If the priority message = 11 ⟶ [Emergency message]

This proposed approach works for the OBU equipped in the vehicles to determine the type of the required message and then transmit it to the RSU. RSU will process the received messages according to their priority. Two alternatives approach are suggested in modeling the process of message queuing:

3.6.1 Approach 1: Single queue for all message

The 1st model approach is to use two processing servers in an RSU. All the received messages (three types) will wait in a single queue according to their arrival times. This model has an ability to process two messages at the same time. When any server state is empty or when it finished its processed message, a searching will make on the waiting messages in a queue, if there any emergency message it will be selected to jump over the preceding messages to process directly. Otherwise, the important message is selected. If no message from the two types is available, a first normal message on the head of the queue will be selected and processed. Figure 3.12 Presents the proposed flowchart to illustrate the data dissemination and the sequence of the processing steps for the 1st model while, figure 3.13 presents the queuing model as a schematic diagram for the proposed servers in the 1st approach.

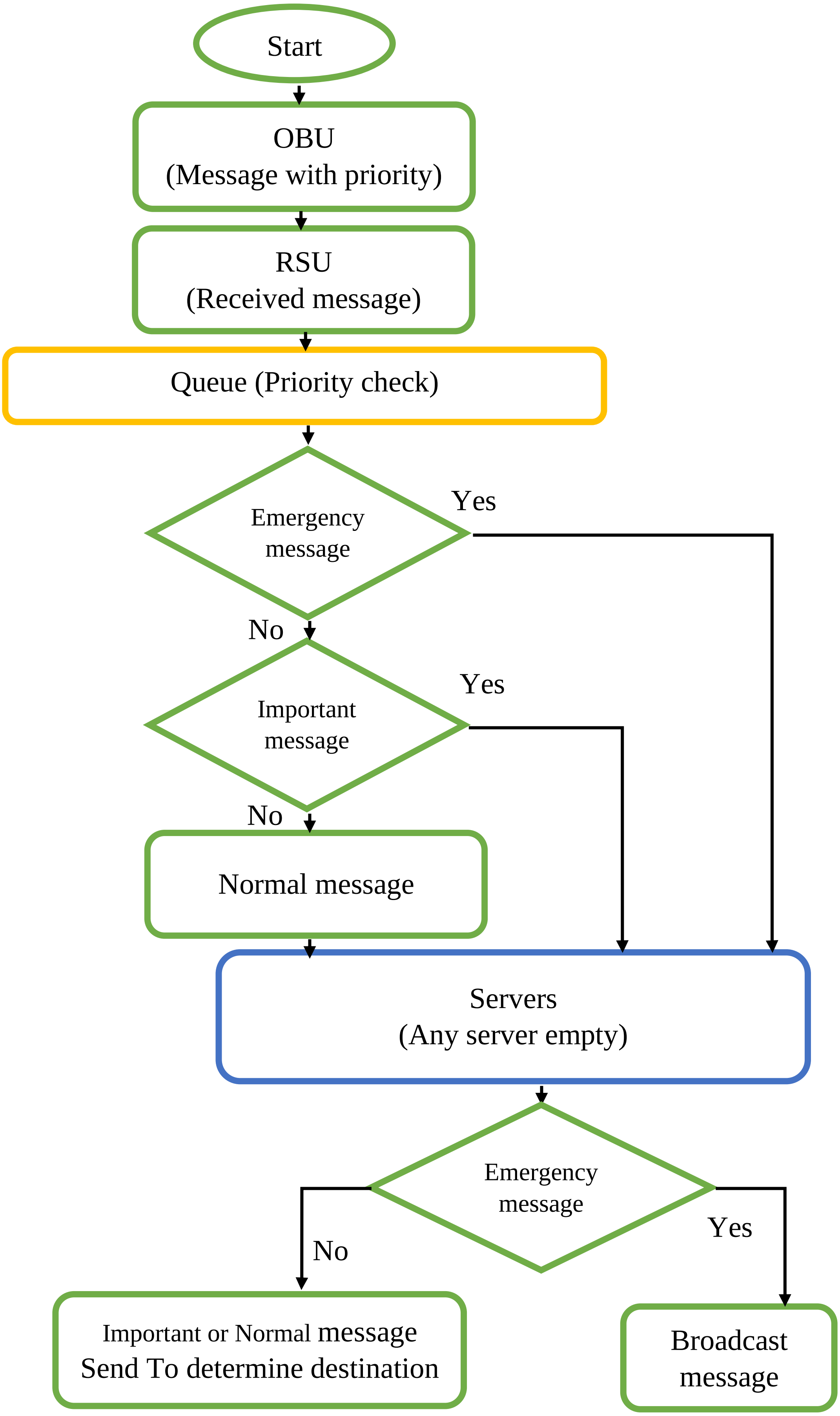


Figure 3.12 proposed data dissemination in the 1st approach.

Algorithm 3.1 proposed data dissemination in the 1st approach.

Initial: In this algorithm, assumed a message from source vehicle on the road where is wanted to send it.

Begin

Step 1: create the queue with FIFO strategy for all message type.

```
set the-q queue:create 0                    // queue for arrival message
```

Step 2: determine the source vehicle that wanted to send a message.

```
ask one-of vehicles [ set size 3    set color red    set label who    set xxcor xcor  set
                 yycor ycor    set fromID who  ]
reset-ticks
```

Step 3: Create a message and give it attributes.

```
set-default-shape ms "letter opened"
create-ms 3 [ set label-color yellow set label who set mm who set xcor xxcor set
             ycor yycor set size 2 set tm timer set priority random 3]
set summ summ + 3                          // number of created messages
```

Step 4: Receiving the message and entering it in the queue, then determining the priority of the message before sending it.

```
ask ms [
if priority = 0 [   queue:insert the-q self ticks             //enter the queue
if (not queue:empty? the-q) [ let serve queue:remove the-q ticks
                                                 //remove first element of the queue
ask serve [ send message]
]  ]
if priority = 1 [  queue:insert the-q self ticks              // enter the queue
if (not queue:empty? the-q) [let serve queue:remove the-q ticks
                                                 //remove first element of the queue
ask serve [ send message]
]   ]
if priority = 2 [ queue:insert the-q self ticks            //enter the queue
if (not queue:empty? the-q) [ let serve queue:remove the-q ticks
                                                 //remove first element of the queue
ask serve [ broadcast]
]   ]
set rec rec + 3                                  //number of sending messages
```

End

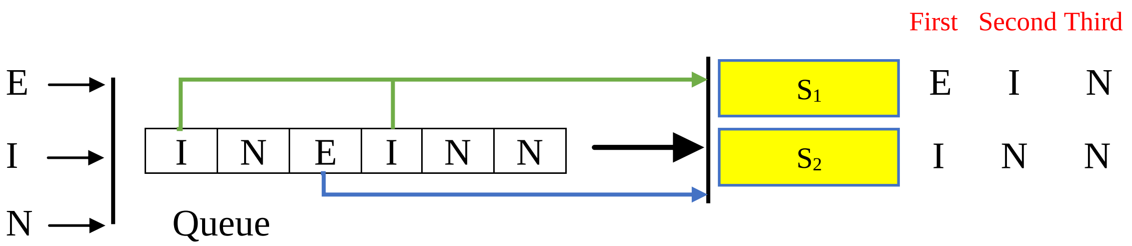


Figure 3.13 Queuing model representation for the 1st approach.

The received messages are nominated as E for the Emergency Message, I for the Important Message, and N for the Normal Message. Si is used to represent the server i.

In the case of figure 3.13, there are several messages that are queued (1 emergency message, 2 important messages, and 3 normal messages) as an example. To process these messages, checking the queuing line first. In the event that there is a message of higher priority than normal messages, it is served according to its priority by transferring it directly to the server for processing. Since they have 2 servers, 2 messages are served together at the same time. In this case, the emergency message and the one important message for the service will be transmitted first, and then 1 important and 1 normal message will be transmitted after the end of the first processing actin.

3.6.2 Approach 2: Multiple queues priority messages

Since we have multiple types of messages and they require high processing traffic due to the movement of vehicles, we need to use multiple channels, that is, more than one server for processing. In the proposed system, three servers were used for each roadside unit. And the use of (weighted) as a scheduling mechanism to distribute the processing of messages on these channels, and also the use of the concept of (parallel queue) for each of the three queues, and the use of the first-in-first-out (FIFO) mechanism to organize the work of the packets.

In the case shown in figure 3.14, the processing process takes place for every 3 messages together, and every time one of the servers is emptied, it receives another message, and so on periodically for all servers.

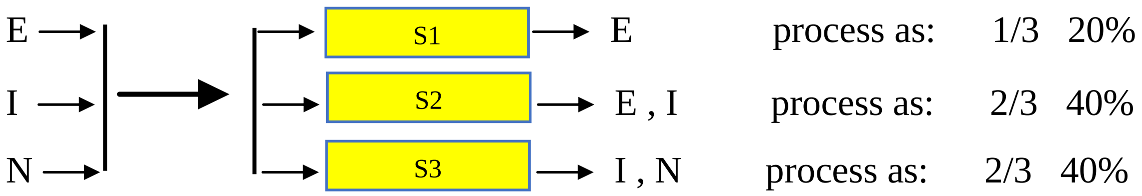


Figure 3.14 Multiple Queuing model representation.

The received messages are nominated as E for the Emergency Message, I for the Important Message, and N for the Normal Message. Si is used to represent the server i.

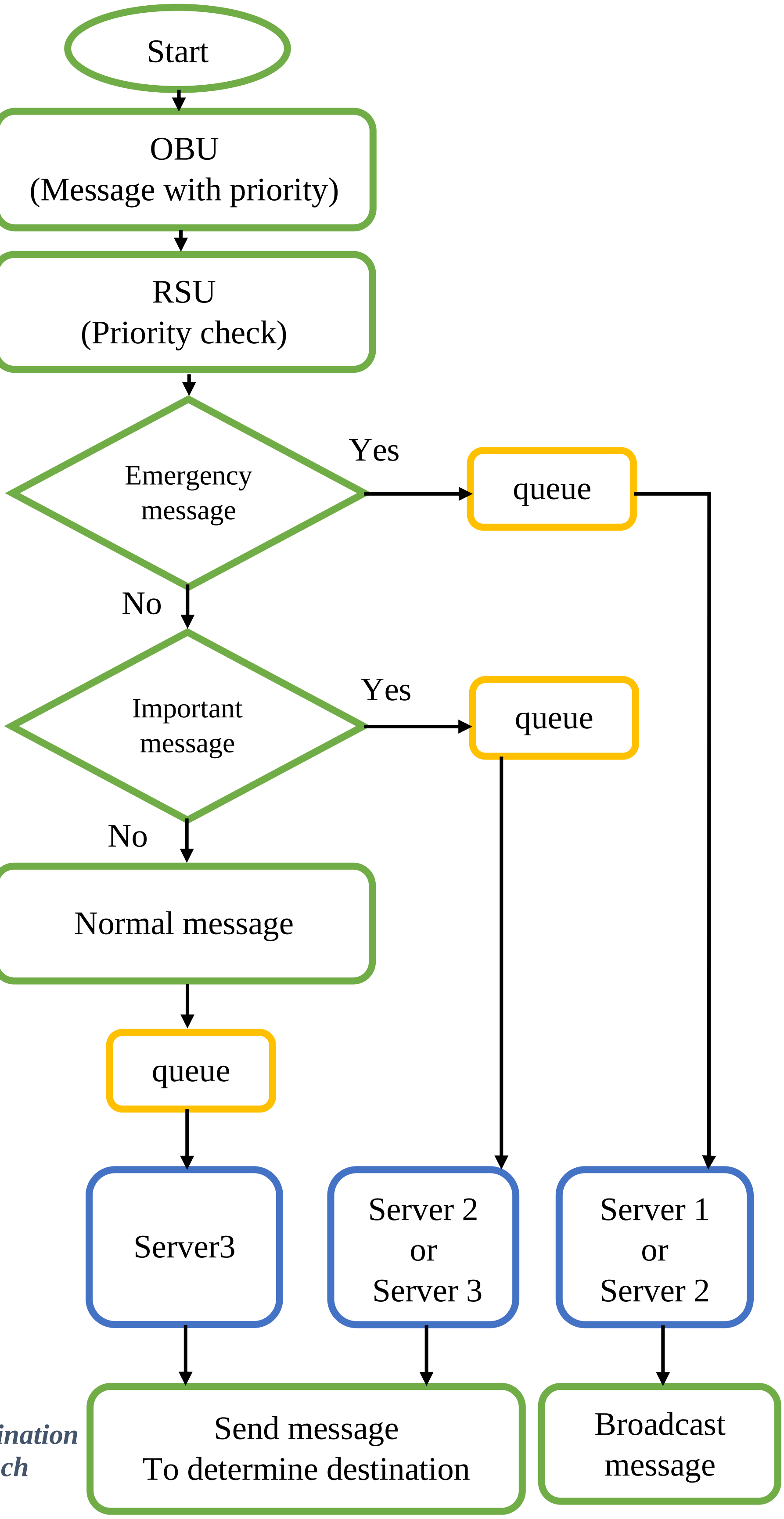


Figure 3.15 proposed data dissemination for the multiple queue approach

Algorithm 3.2 proposed data dissemination for the multiple queue approach

Initial: In this algorithm, assumed an message from source vehicle on the road where is wanted to send it.

Begin

Step 1: create the queue with FIFO strategy for all message type.

```
set the-qE queue:create 0          // queue for Emergency message
set the-qI queue:create 0          // queue for Important message
set the-qN queue:create 0          // queue for Normal message
```

Step 2: determine the source vehicle that wanted to send a message.

```
ask one-of vehicles [ set size 3  set color red  set label who  set xxcor xcor  set
        yycor ycor  set fromID who ]
reset-ticks
```

Step 3: Create a message and give it attributes.

```
set-default-shape ms "letter opened"
create-ms 3 [ set label-color yellow set label who set mm who set xcor xxcor set
      ycor yycor set size 2 set tm timer set priority random 3]
set summ summ + 3                        // number of created messages
```

Step 4: Receiving the message and entering it in the queue, then determining the priority of the message before sending it.

```
ask ms [
if priority = 0 [  queue:insert the-qN self ticks          //enter the queue
if (not queue:empty? the-qn) [ let serve queue:remove the-qn ticks
                                           //remove first element of the queue
ask serve [ send message]
] ]
if priority = 1 [  queue:insert the-qI self ticks          // enter the queue
if (not queue:empty? the-qI) [let serve queue:remove the-qI ticks
                                           //remove first element of the queue
ask serve [ send message]
]  ]
if priority = 2 [ queue:insert the-qE self ticks           //enter the queue
if (not queue:empty? the-qE) [ let serve queue:remove the-qE ticks
                                           //remove first element of the queue
ask serve [ broadcast]
]  ]
set rec rec + 3                            //number of sending messages
```

End

Data transmission is implemented (based on the proposed clustering approach). The evaluation process of the proposed algorithm for data transmission approach are calculated with different parameters, the average throughput, delay, packet loss, packet delivery ratio, probability, difference in time and time of waiting as the efficiency of the data transmission algorithm indicates.

- **Assumptions:**

  S_i = number of servers

  m_i = message type, where

  E = Emergency message

  I = Important message

  N = Normal message

- In this model, three servers are considered to process three types of messages.
- When s_1 is empty, any message that arrives of type (E) enters server number (1).
- If s_1 busy and s_2 is empty, then any message of type (E) or (I) will enter server number (2).
- If s_2 busy but s_3 is empty, the message of type (I) or (N) will enter server number (3).
- Other than that, any message of type (N) will enter server number (3).

That's mean:

- In the case of s_1 busy and s_2 busy, the message of type (E) is entered into queue.
- In the case of s_2 busy and s_3 busy, the message of type (I) is entered into queue.
- In the case of s_3 busy, the message of type (N) is entered into queue.

Table 3.1 List of variables assumptions

Notation	Description
λ_0	Total of arrivals
$\lambda 1$	Arrival rate for Emergency message
$\lambda 2$	Arrival rate for Important message
$\lambda 3$	Arrival rate for Normal message
$\sigma 1$	The total arrivals rate relative to one arrival rate of a particular type of message
p	probability in the system
$P0$	The probability of the system is empty
L	Number of messages in the system (server and queue)
Wq	The time a message waits in the queue before processing

From that we get:

$\lambda_0 = \lambda_1 + \lambda_2 + \lambda_3$ *Equation 3.4 Total of arrivals messages*

$\lambda_i = \lambda$ where: i = 1,2,3

In the same previous manner:

$\sigma 1 = \frac{\lambda 1 + \lambda 2 + \lambda 3}{\lambda 1}$ *Equation 3.5 total arrivals rate relative to one arrival rate*

$P0 = \frac{1-p}{1-p+\sigma p}$ *Equation 3.6 The probability of the system is empty*

$P = \frac{\lambda}{\mu}$ *Equation 3.7*

$L = \frac{\sigma 1 .P}{(1-P)(1-P+\sigma 1\, P)}$ *Equation 3.8 Number of messages in the system*

$Wq = \frac{\sigma 1 .P}{(1-P+\sigma 1\, P)(1-P)\mu 1}$ *Equation 3.9 time a message waits in the queue*

CHAPTER FOUR

Result and Discussions

4 CHAPTER FOUR

Result and Discussions

4.1 Introduction

This chapter aims to present and discuss the results of the proposed curricula through several performance measures. A scenario was designed to simulate a real-world environment using Netlogo 6.3.0 simulation. After presenting the results, they are discussed to show the impact of the proposed model on improving transport networks and their performance measures. In context of information diffusion models, the analysis is done to highlight whether diffusion model is suitable for real time applications or to other applications. On the other hand, comparison between the proposed models and the promising related model is done to emphasize that the proposed models are related to the well-known models.

This chapter is organized in five sections including the introduction. The second section is dedicated to environment creation. The third section explains the simulation environment. The fourth section explains the mechanism and results of the proposed Clustering Approach. The fifth section clarifies the mechanisms and results of the proposed Data Dissemination Approach.

4.2 Environment Creation

In Chapter 3, an improved approach was proposed based on the static clustering center-based mechanism to provide the best coverage and connectivity to achieve vehicle communication with the least possible link failure, while maintaining sending messages according to multiple priorities to avoid losing messages that may cause accidents or problems on the road.

This helps provide an optimization data transmutation rate in ITS. The simulation environment has been created as follows:

- It consists of a street that contains a variable number of lanes of the road.
- As indicated in the third chapter, the roadside unit has been installed with a distance of 1000 meters between one unit and the other.
- Vehicles were generated for the region based on a probability random function depending on the time of arrival.
- Generating and building speeds of cars according to mention in third chapter.
- Applying Algorithm 3.1 mentioned in third chapter to work and calculate the number of links (the number of vehicles) associated with each RSU.
- When there is a need to send data between vehicles, the button "send messages" is pressed through the first or second approach proposed in this thesis.

Figure 4.1 provides a simulated snapshot as an implementation sample. The towers represent the RSU acting as CH while the vehicles within their field are represented as CMs, where the vehicles are connected to the nearby RSU according to the transmission radius. If the car is covered by two RSUs, it will be connected to the strongest signal.

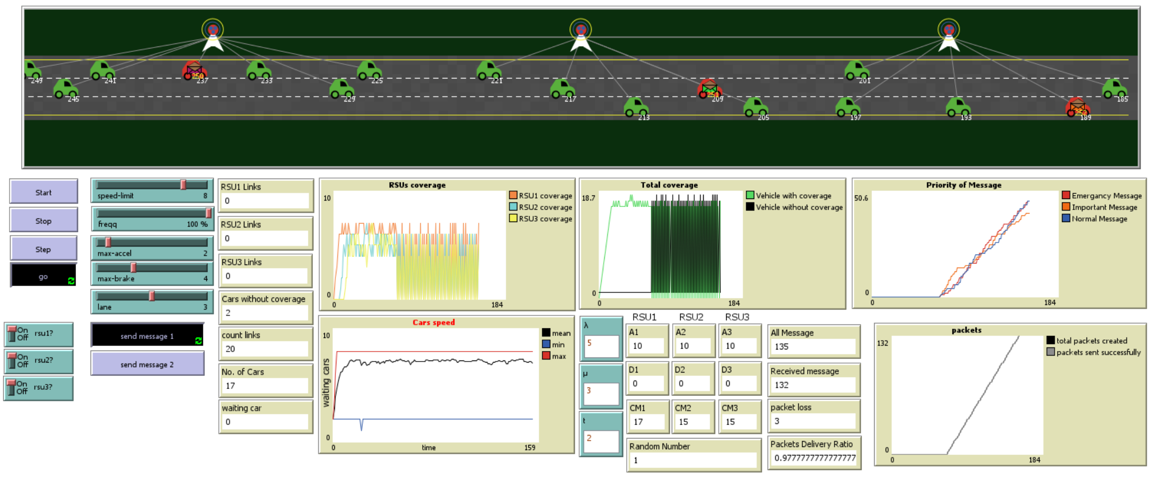


Figure 4.1 Simulation snapshot

4.3 Simulation Environment

After designing and running the navigation model approach using static clustering and the proposed data-priority deployment approach according to the simulation environment creation, the results were collected and displayed using the Netlogo 6.3.0 Results Viewer. The proposed simulation environment setup is shown in Table 4.1.

Table 4.1 Simulation Environment setup

Simulator	**Netlogo 6.3.0**
Number of Simulation Run	10
RSU coverage area	1 km
Arrival rate	Variable (t)
Departure rate	Variable (t)
Speed distribution	Exponential
Acceleration	variable m/s
Deceleration	variable m/s
Scenario environment	Highway
Street length	6 km
Number of lanes	variable
Very short time period.	Δt

4.4 Scenarios to simulate proposed clustering approach

As explained in the third chapter, this clustering mechanism has been applied to roadside units as a (spatial cluster) where each RSU is responsible of covering its own area, and any vehicle within a particular RSU area connects to it, and then starts communicating in the network and exchanging information.

4.4.1 Clustering Results

As mentioned in the third chapter, the process of evaluating the proposed algorithm for clustering depends on the previously mentioned performance measures, and accordingly, the mentioned mechanism was applied to several different experiments were carried out and analyzed to observe the clusters in different simulations of different highway VANET environments.

The number of compounds in each group was observed and indicated at different consecutive times. The difference in the arrival and departure of the number of cluster compounds at successive times is used as an indicator about the behavior of the clustering process.

Case 1: fixed departure rate with variable arrival rate in each time period

In this case, as shown in tables (4.2, 4.3, 4.4), the results represent values from 10 test of the clusters to evaluate the stability when the departure rate is fixed with each time period, and the arrival rate is variable.

- Stage1: $\lambda = 5$ $\mu = 3$ $\Delta t = 2$ R= random number

$A(\Delta t) = \lambda * (\Delta t)$
$A(\Delta t) = 5 * 2$
$A(\Delta t) = 10$

$D(\Delta t) = \mu * (\Delta t)$
$D(\Delta t) = 3 * 2$
$D(\Delta t) = 6$

Table 4.2 Case1: Results when departure rate fixed and arrival rate variable- stage 1

ticks	Cluster 1					Cluster 2				Cluster 3			
	R	A (Δt)	D (Δt)	N (t)	CMs ($t+\Delta t$)	A (Δt)	D (Δt)	N (t)	CMs ($t+\Delta t$)	A (Δt)	D (Δt)	N (t)	CMs ($t+\Delta t$)
1	1	10	0	7	17	10	0	6	16	10	0	8	18
2	9	0	6	17	11	0	6	16	10	0	6	18	12
3	3	10	0	11	21	10	0	10	20	10	0	12	22
4	7	0	6	21	15	0	6	20	14	0	6	22	16
5	3	10	0	15	25	10	0	14	24	10	0	16	26
6	5	10	0	25	35	10	0	24	34	10	0	26	36
7	1	10	0	35	45	10	0	34	44	10	0	36	46
8	8	0	6	45	39	0	6	44	38	0	6	46	40
9	9	0	6	39	33	0	6	38	32	0	6	40	34
10	2	10	0	33	43	10	0	32	42	10	0	34	44
Range	34					34				34			
Mean	25.75384					24.62977				26.86595			
Std	12.22202					12.22202				12.22202			

- Stage2: $\lambda = 6$ μ = 3 $\Delta t = 2$ R= random number

A (Δt) = λ * (Δt)
A (Δt) = 6 * 2
A (Δt) = 12

D (Δt) = μ * (Δt)
D (Δt) = 3 * 2
D (Δt) = 6

Table 4.3 Case1: Results when departure rate fixed and arrival rate variable- stage 2

ticks	Cluster 1					Cluster 2				Cluster 3			
	R	A (Δt)	D (Δt)	N (t)	CMs ($t+\Delta t$)	A (Δt)	D (Δt)	N (t)	CMs ($t+\Delta t$)	A (Δt)	D (Δt)	N (t)	CMs ($t+\Delta t$)
1	3	12	0	7	19	12	0	6	18	12	0	8	20
2	4	12	0	19	31	12	0	18	30	12	0	20	32
3	8	0	6	31	25	0	6	30	24	0	6	32	26
4	2	12	0	25	37	12	0	24	36	12	0	26	38
5	9	0	6	37	31	0	6	36	30	0	6	38	32
6	7	0	6	31	25	0	6	30	24	0	6	32	26
7	1	12	0	25	37	12	0	24	36	12	0	26	38
8	8	0	6	37	31	0	6	36	30	0	6	38	32
9	5	12	0	31	43	12	0	30	42	12	0	32	44
10	9	0	6	43	37	0	6	42	36	0	6	44	38
Range	24					24				24			
Mean	30.80912					29.77978				31.83633			
Std	7.183314					7.183314				7.183314			

- Stage3: $\lambda = 7$ μ = 3 $\Delta t = 2$ R= random number

A (Δt) = λ * (Δt)
A (Δt) = 7 * 2
A (Δt) = 14

D (Δt) = μ * (Δt)
D (Δt) = 3 * 2
D (Δt) = 6

Table 4.4 Case1: Results when departure rate fixed and arrival rate variable- stage 3

ticks	Cluster 1					Cluster 2				Cluster 3			
	R	A (Δt)	D (Δt)	N (t)	CMs (t+Δt)	A (Δt)	D (Δt)	N (t)	CMs (t+Δt)	A (Δt)	D (Δt)	N (t)	CMs (t+Δt)
1	1	14	0	7	21	14	0	6	20	14	0	8	22
2	8	0	6	21	15	0	6	20	14	0	6	22	16
3	6	14	0	15	29	14	0	14	28	14	0	16	30
4	9	0	6	29	23	0	6	28	22	0	6	30	24
5	7	0	6	23	17	0	6	22	16	0	6	24	18
6	6	14	0	17	31	14	0	16	30	14	0	18	32
7	8	0	6	31	25	0	6	30	24	0	6	32	26
8	9	0	6	25	19	0	6	24	18	0	6	26	20
9	7	0	6	19	13	0	6	18	12	0	6	20	14
10	4	14	0	13	27	14	0	12	26	14	0	14	28
Range		18				18				18			
Mean		21.21411				20.1726				22.25147			
Std		6.055301				6.055301				6.055301			

Case 2: fixed arrival rate with variable departure rate in each time period

In this case, a shown in tables (4.5, 4.6, 4.7), the results represent values from 10 test of the clusters to evaluate the stability when the arrival rate is fixed with each time period, and the departure rate is variable.

- Stage1: $\lambda = 4$ μ = 3 $\Delta t = 2$ R= random number

A (Δt) = λ * (Δt)
A (Δt) = 4 * 2
A (Δt) = 8

D (Δt) = μ * (Δt)
D (Δt) = 3 * 2
D (Δt) = 6

Table 4.5 Case2: Results when arrival rate fixed and departure rate variable - stage 1

ticks	Cluster 1					Cluster 2				Cluster 3			
	R	A (Δt)	D (Δt)	N (t)	CMs $(t+\Delta t)$	A (Δt)	D (Δt)	N (t)	CMs $(t+\Delta t)$	A (Δt)	D (Δt)	N (t)	CMs $(t+\Delta t)$
1	7	0	3	7	4	0	3	6	3	0	3	8	5
2	6	4	0	4	8	4	0	3	7	4	0	5	9
3	9	0	3	8	5	0	3	7	4	0	3	9	6
4	8	0	3	5	2	0	3	4	1	0	3	6	3
5	3	4	0	2	6	4	0	1	5	4	0	3	7
6	6	4	0	6	10	4	0	5	9	4	0	7	11
7	2	4	0	10	14	4	0	9	13	4	0	11	15
8	1	4	0	14	18	4	0	13	17	4	0	15	19
9	7	0	3	18	15	0	3	17	14	0	3	19	16
10	9	0	3	15	12	0	3	14	11	0	3	16	13
Range	16					16				16			
Mean	7.83425					6.470539				9.052914			
Std	5.274677					5.274677				5.274677			

- Stage2: $\lambda = 4$ $\mu = 4$ $\Delta t = 2$ R= random number

$$A(\Delta t) = \lambda * (\Delta t)$$
$$A(\Delta t) = 4 * 2$$
$$A(\Delta t) = 8$$

$$D(\Delta t) = \mu * (\Delta t)$$
$$D(\Delta t) = 4 * 2$$
$$D(\Delta t) = 8$$

Table 4.6 Case2: Results when arrival rate fixed and departure rate variable - stage 2

ticks	Cluster 1					Cluster 2				Cluster 3			
	R	A (Δt)	D (Δt)	N (t)	CMs $(t+\Delta t)$	A (Δt)	D (Δt)	N (t)	CMs $(t+\Delta t)$	A (Δt)	D (Δt)	N (t)	CMs $(t+\Delta t)$
1	8	8	0	7	15	8	0	6	14	8	0	8	16
2	7	8	0	15	23	8	0	14	22	8	0	16	24
3	5	0	8	23	15	0	8	22	14	0	8	24	16
4	3	0	8	15	7	0	8	14	6	0	8	16	8
5	9	8	0	7	15	8	0	6	14	8	0	8	16
6	8	8	0	15	23	8	0	14	22	8	0	16	24
7	7	8	0	23	31	8	0	22	30	8	0	24	32
8	5	0	8	31	23	0	8	30	22	0	8	32	24
9	3	0	8	23	15	0	8	22	14	0	8	24	16
10	1	0	8	15	7	0	8	14	6	0	8	16	8
Range	24					24				24			
Mean	15.74384					14.60563				16.85949			
Std	7.589466					7.589466				7.589466			

- Stage3: $\lambda = 4$ µ = 5 $\Delta t = 2$ R= random number

A (Δt) = λ * (Δt)
A (Δt) = 4 * 2
A (Δt) = 8

D (Δt) = µ * (Δt)
D (Δt) = 5 * 2
D (Δt) = 10

Table 4.7 Case2: Results when arrival rate fixed and departure rate variable - stage 3

ticks		Cluster 1				Cluster 2				Cluster 3			
	R	A (Δt)	D (Δt)	N (t)	CMs (t+Δt)	A (Δt)	D (Δt)	N (t)	CMs (t+Δt)	A (Δt)	D (Δt)	N (t)	CMs (t+Δt)
1	1	8	0	7	15	8	0	6	14	8	0	8	16
2	6	8	0	15	23	8	0	14	22	8	0	16	24
3	9	0	10	23	13	0	10	22	12	0	10	24	14
4	2	8	0	13	21	8	0	12	20	8	0	14	22
5	7	0	10	21	11	0	10	20	10	0	10	22	12
6	8	0	10	11	1	0	10	10	0	0	10	12	2
7	6	8	0	1	9	8	0	0	8	8	0	2	10
8	2	8	0	9	17	8	0	8	16	8	0	10	18
9	1	8	0	17	25	8	0	16	24	8	0	18	26
10	8	0	10	25	15	0	10	24	14	0	10	26	16
Range		24				24				24			
Mean		11.95115				14.68667				13.57519			
Std		7.118052				7.118052				7.118052			

4.4.2 Evaluation the Proposed Clustering Approach

As it was explained in the results of the previous section, in case 1: fixed departure rate with variable arrival rate in each time period represented by tables (4.2, 4.3, 4.4), the analysis scheme of these tables shown in Figure 4.2 shows that the range of clustering in each stage decreases as the value of arrival rate increases with the fixed of departure rate as it is shown in the first table (stage 1) with a value of 34 and the second table (stage 2) with a value of 24 and in the third table (stage 3) with value of 18. The value of standard division of clustering in each stage tends to decrease as the arrival rate increases with fixed departure. As for the value of the mean of clustering in each stage, it maintains a stable range.

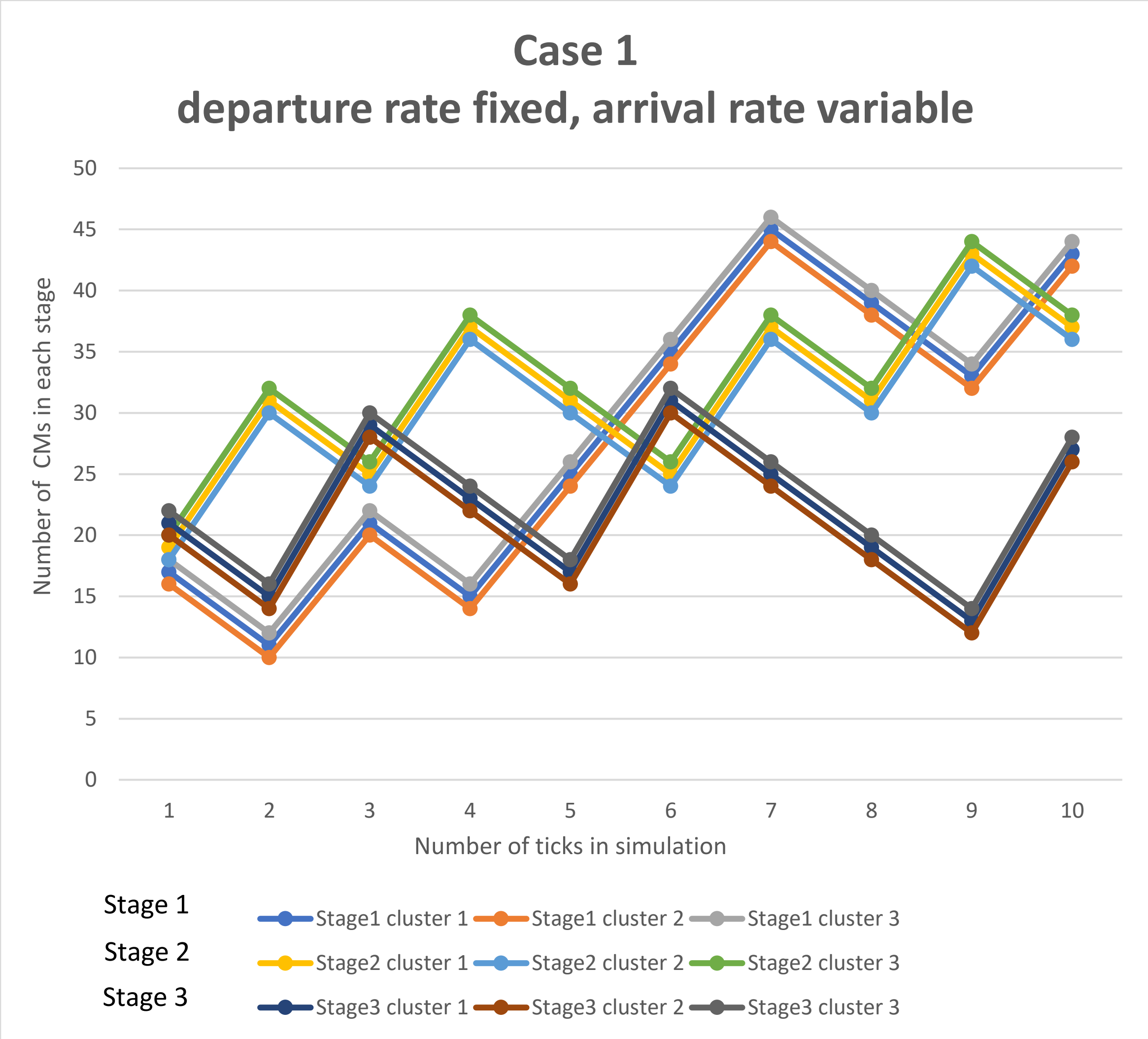


Figure 4.2 Case1: Results when departure rate fixed and arrival rate variable

In case 2: fixed arrival rate with variable departure rate in each time period represented by tables (4.5, 4.6, 4.7), the analysis scheme of these tables shown in Figure 43 shows that the range of clustering in each stage increases as the value of departure rate increases with the fixed of arrival rate as it is shown in the first table (stage 1) with a value of 16, the second table (stage 2) and the third table (stage 3) with value of 24. The value of standard division of clustering in each stage tends to increase as the departure rate increases with fixed arrival. As for the value of the mean of clustering in each stage, it maintains a stable range.

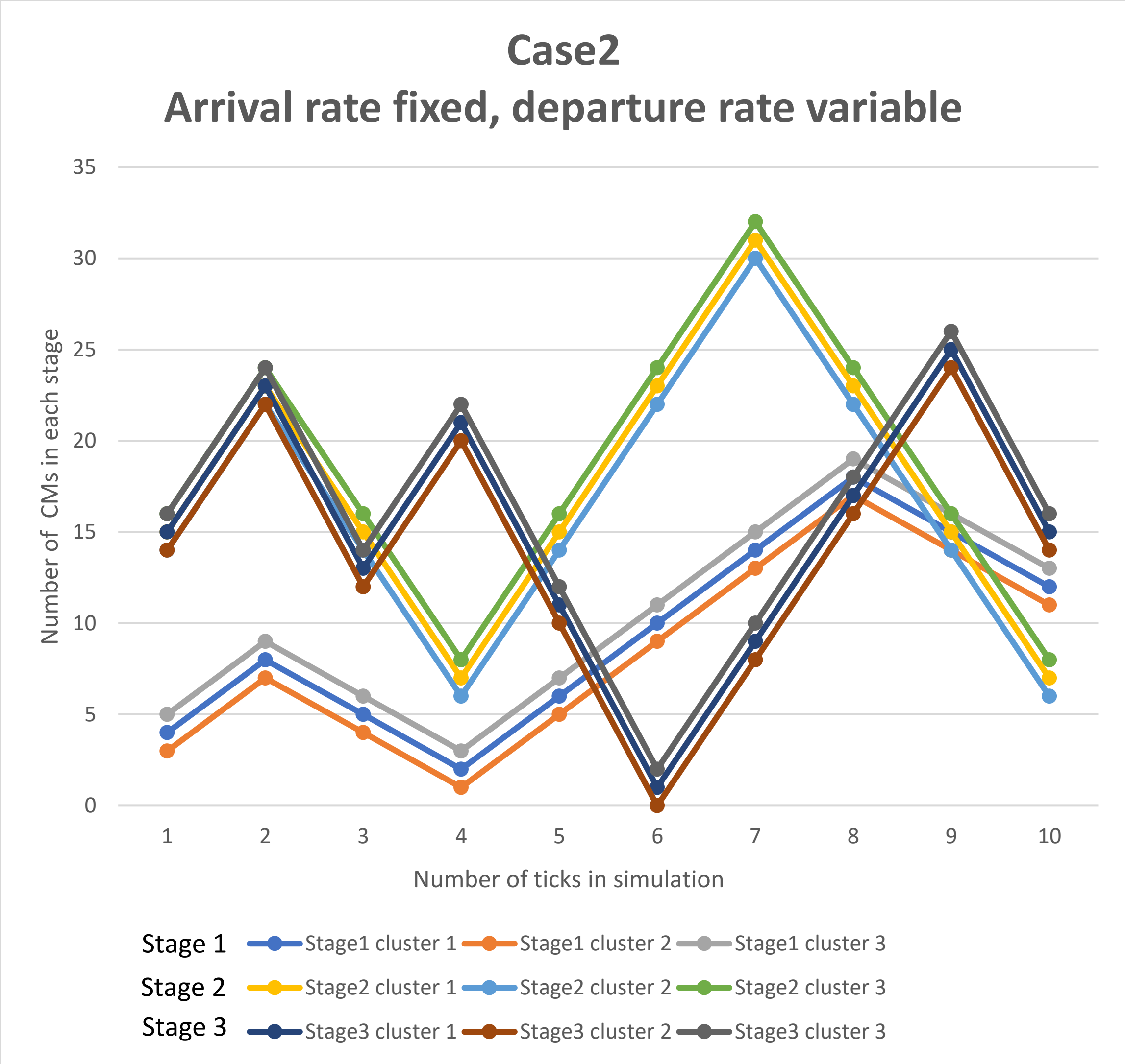


Figure 4.3 Case2: Results when arrival rate fixed and departure rate variable

After experimenting with the two cases and taking the results and analyzing them, as the graphs show, it is clear that the proposed clustering method gives a better result in terms of stability. This achieves greater connectivity for each cluster member as well as better coverage due to the correct distribution of the RSU. As well as reducing the problem of failure of communication or mobility between vehicles, since the vehicle is connected to the stronger coverage by signal if it is between two coverages of the two RSU. These conclusions logically lead to a greater possibility of improving the data transfer rate between vehicles and infrastructure.

4.5 Scenarios to simulate proposed data dissemination approach

As explained in the third chapter, when the performance metrics are calculated with different parameters, enter server, server time, idle, waiting queue time and others (according to Equations (3.5), (3.6), (3.7), (3.8) and (3.9) respectively) are obtained as part of the evaluation of the proposed system.

4.5.1 Approach 1: single queue for all message

This approach handles messages by the server regardless of their type, but according to their priority directly, as explained in Chapter 3. assumed here that there are 10 types of messages that have arrived at the RSU for processing in RSU severs at every moment. Messages are of different types, pre-defined by the vehicle, as shown in the (Type) field. Enters at different times shown in the access field, then follows stages, including server entry, processing, delay time, and other values, which are calculated and explained in Table 4.8.

Table 4.8 simulation for Approach 1

Ticks	Type	Inter arrival	Arrival	Server 1					Server 2				
				W1	Idle1	Enter Serves1	Serves Time1	D1	W2	Idle2	Enter Serves2	Serves Time2	D2
1	N	5	5	0	5	5	7	12					
2	I	2	7						0	7	7	3	10
3	E	1	8						2	0	10	9	19
4	E	3	11	1		12	5	17					
5	I	4	15	2		17	8	25					
6	N	6	21						0	2	21	8	29
7	N	8	29		4	29	6	35					
8	E	2	31						0	2	31	5	36
9	I	1	35	0	0	35	3	38					
10	E	3	34				6		2		36	8	44

4.5.2 Approach 2: Multiple queues for every message

This approach processes messages by the server according to their type and priority in the server, as explained in Chapter 3. Assumed here that there are 11 types of messages that have arrived at the server for processing at each moment. Messages are of different types, pre-defined by the vehicle, as shown in the (Type) field. It enters at different times shown in the access field, then follows stages, including server entry, processing, delay time, and other values, which are calculated and explained in Table 4.9.

Table 4.9 simulation for Approach 1

				Server 1					Server 2					Server 3				
Ticks	**Type**	**Inter arrival**	**Arrival**	**W1**	**Idle1**	**Enter Serves1**	**Serves Time1**	**D1**	**W2**	**Idle2**	**Enter Serves2**	**Serves Time2**	**D2**	**W2**	**Idle2**	**Enter Serves2**	**Serves Time2**	**D2**
1	N	7	7											0	7	7	10	17
2	I	9	16						0	16	16	10	26					
3	I	10	26											0	9	26	11	37
4	E	8	34	0	34	34	12	46										
5	N	7	41												4	41	9	50
6	N	6	47											3	0	50	13	63
7	N	5	52											11	0	63	10	73
8	N	9	61											12	0	73	5	78
9	E	3	64	0	18	64	12	76										
10	I	4	68						0	42	68	12	80					
11	N	2	70											8	0	78	6	84

4.5.3 Evaluation the Proposed data dissemination approach

In approach 1, after analyzing and evaluating the table 4.9 above, appears according to the scheme shown in Figure 4.4, that the first server had processed 2 Emergency messages, 2 Important messages, and 2 Normal messages at different times, depending on the time and load of the server1. The second server had processed 3 Emergency messages, 1 Important message, and 1 Normal message at different times, depending on the time and load of the server2. Thus, all incoming messages were processed without wasting the most important messages, since the processing is carried out according to priority.

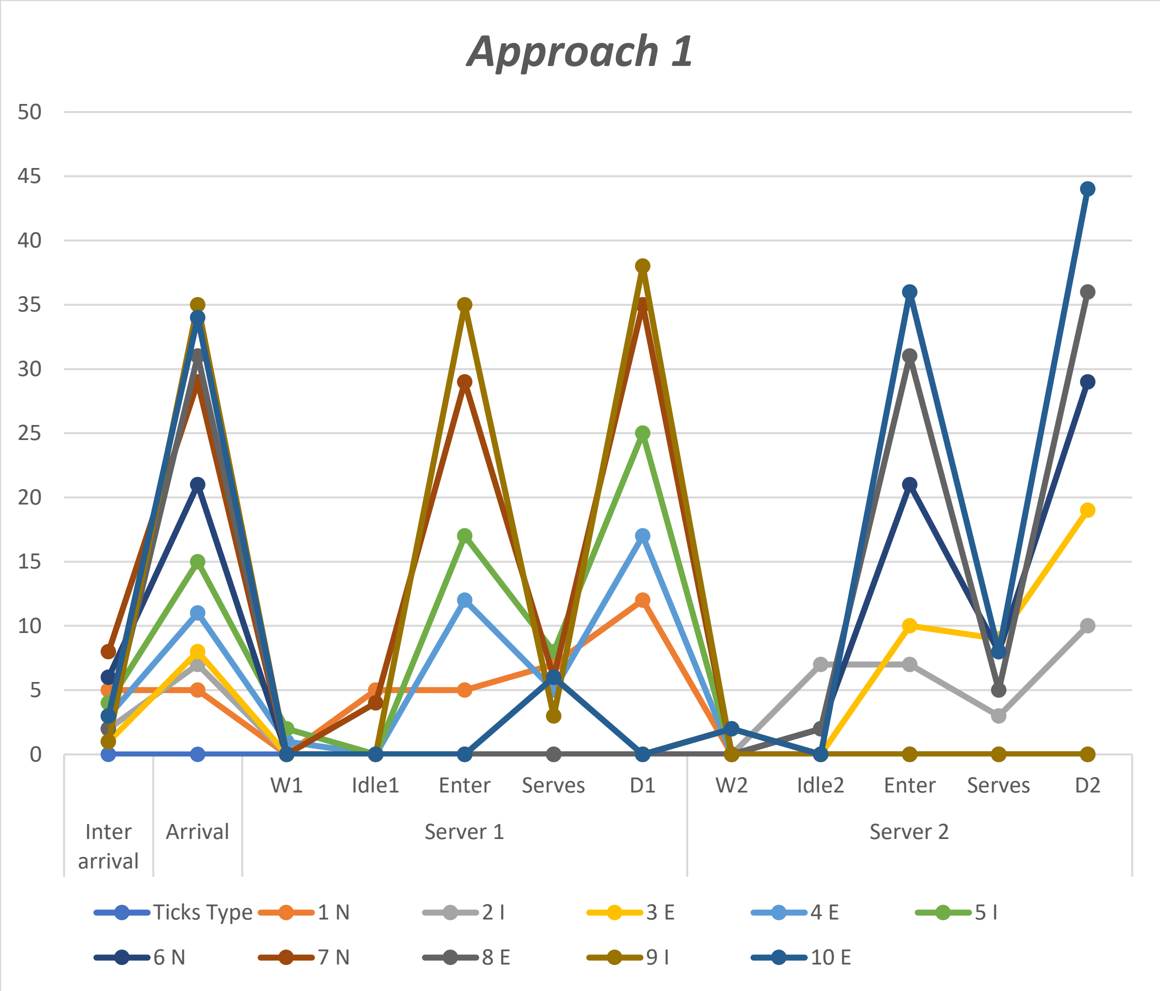


Figure 4.4 Analysis results for the 1st approach

In approach 2, after analyzing and evaluating the table 4.9, appears according to the scheme shown in Figure 4.5, that the first server had processed 2 Emergency messages, the second server had processed 2 Important message and the third server had processed 1 Important and 6 Normal messages.

This processing done according to the type of messages and the servers. For emergency messages, servers 1 and 2 are designated for processing them. In this case, two emergency messages were received at times (3 and 8), and at these two times, server 1 is empty, so processing done without need to going for server 2.

As for important messages, servers No. 2 and 3 are dedicated to processing them. In this case, 3 important messages arrived at times (4, 9, 10). When a message arrives at time 4, server 2 is empty and processes. The same case is for the message arrived at time 9. But when the message arrives at time 10, the server 2 is still processing the message arrived at time 9, so turns to server 3 for processing. As for normal messages, the third server is responsible for processing them all. Thus, all incoming messages were processed without wasting the most important messages, since the processing is carried out according to priority.

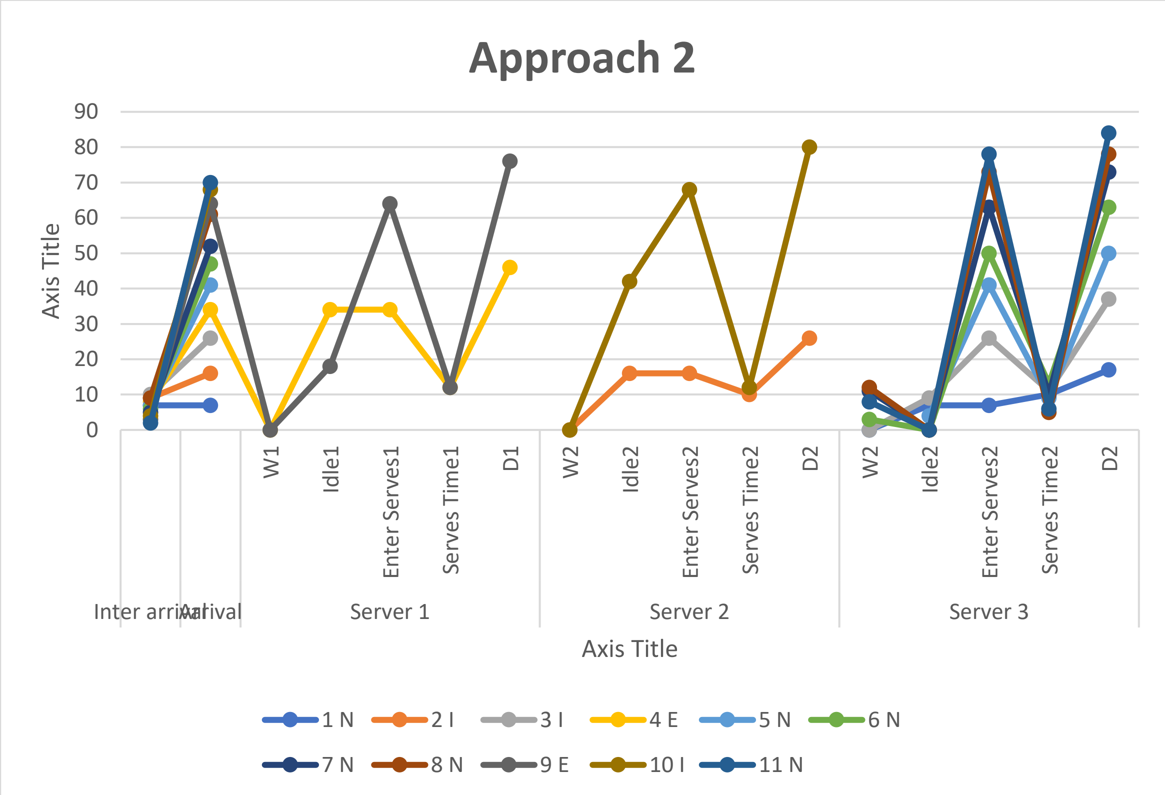


Figure 4.5 Analysis results for the 2ed approach

After experimenting with the two cases and taking the results and analyzing them, and as the graphs show, it is clear that the method of data transmission proposed in the first proposal is to process messages as soon as they reach the RSU with the least possible waiting and with an equal distribution of the load for processing (processing different types of messages according to the server load). As for the second proposal, the speed in processing emergency and important messages was observed with a small waiting in relation to normal messages and with a different distribution based on the type of messages and service provision in the RSU (processing a specific type of message according to the specific type of server).

CHAPTER FIVE

Conclusions and future works

5 CHAPTER FIVE
Conclusion and future works

5.1 Introduction

The advent of Vanet Networks has greatly advanced the Intelligent Transport System (ITS) in various applications. In view of the Vanet environment, there must be a mechanism that guarantees communication in the best possible way and spreads data between vehicles in a way that ensures the importance of that data as it causes accidents and crises. Vehicle communication and data dissemination in Vanet relies on several mechanisms, all of which seek to develop and improve data communication and transmission between vehicles, thus reducing problems and the number of accidents on the road. In this thesis, it is proposed to use static grouping technique based on roadside modules to ensure the best communication coverage of vehicles. It was also suggested to use priority to ensure that the data reaches the highest percentage of vehicles, especially messages with higher priorities.

This chapter is to preview the conclusions of the proposed models which are inferred from the performance metrics. These conclusions are taken based on the simulation experiments in a virtual VANET environment

5.2 Conclusions

In this study, a model was built using Net Logo 6.3.0 simulation. It contains one road with three lanes (the number of lanes can be changed). In this proposed model, the communication within the network will be of the central type with the roadside unit when the vehicles are within the range of the RSU. Data is published according to its priority to keep it from being lost.

5.2.1 Clustering Stage Conclusions

The spatial cluster center-based technique with RSU has been proposed. Clustering is one of the techniques used in data dissemination used in this thesis with the static cluster distribution within the RSU range in network to obtain a stable network.

This thesis crones up with the following conclusions:

- The clustering approach is used to describe each RSU as a head of a fixed cluster, and each vehicle approaching the domain of that cluster shares its location or road area characteristic and is a member of the cluster.
- A message is sent periodically to all vehicles that approach the range of the RSU unit to give the RSU ID to the vehicles for communication, and in the event that there is a vehicle within the range that does not have the RSU ID, they will be sent to the network.
- In the event of transferring a car from one cluster to another (i.e., a transfer area between the two clusters), the vehicle is connected to the stronger RSU by signal.
- Evaluation scales were adopted in this thesis by relying on the arrival and departure rates of vehicles and comparing them in terms of Range, Mean, Standard divtion.
- When conducting experiments on the proposed system and implementing the cluster approach on several variables, it appeared that the values are increasing or decreasing depending on the rates of arrival and departure in relation to time.

5.2.2 Data Dissemination Stage Conclusions

The dissemination of data in vehicle networks represents a major challenge and an area for analyzing and evaluating the performance and problems of road networks. It is possible to anticipate and monitor traffic, predict accidents and congestion, and find continuous solutions by analyzing the data spread continuously on the network. The behavior of some types of messages was examined and analyzed according to importance. In this thesis, three types of messages with different priorities considered in a real data set. Develop a valid model built and implemented based on dataset information to examine data propagation and avoid missing important messages. The development of such models will help avoid accidents, disasters and traffic congestion and facilitate the passage of emergency vehicles on the roads.

5.3 Limitation

The set of restrictions imposed in this thesis are as follows:

1. The vehicles are equipped with all the devices that help them communicate with RSU.

2. The process of sending and receiving data between vehicles is within a record time to match the speed of movement of vehicles on the highways, based on the development in technology and the work of researchers in the future.

3. Also assumed that the network used is ideal and where the connections are free of noise and protected from various types of hacker attacks.

5.4 Future Works

Although this thesis illustrates that the suggested framework gives high performance, future research to expand the work in this thesis can involve:

- Implementing the proposed approach in urban or rural environments.
- Implementing many data dissemination approaches in VANET (Geographical Forwarding, Opportunistic Forwarding) in two designed models and comparing them.
- Modifying the proposed approach by add aspects that have not been considered in this thesis and are thought to affect data dissemination, such as big vehicles that may have an unfavorable effect on delivering messages. For example, larger vehicles can forward a weak signal to their destination, and, on the other side, they may block a strong signal from reaching its destination.
- Clustering has been implemented using roadside units, the receiver can create a back-up system from one vehicle to another to communicate in case of communication problems with the RSU in emergency situations.

- Applying the proposed approach to configure two roads in different directions, to evaluate the performance of the servers, and then compare the two works.
- The ability of connecting vehicles to the Internet via a vehicle sim vehicle with 5G and thus obtaining information directly from the source such as a street map and thus sending and receiving data through a dedicated platform.
- Bringing about technological development in the field of security, which is one of the essential duties of the Ministry of Interior. For example, when they are robbed, vehicles can create and disseminate periodic messages about their location and destination, thus making it easier for security men to reach them and catch the thief.
- Internet of Vehicle (IoV), which is a new concept that has entered the world of vehicle networks, experimented with the proposed approach, whether through communication operations, data dissemination, or the use of applications.

References

Abbas, G., Abbas, Z. H., Haider, S., Baker, T., Boudjit, S., & Muhammad, F. (2019). PDMAC: A priority-based enhanced TDMA protocol for warning message dissemination in VANETs. Sensors, 20(1), 45.

Abuashour, A., & Kadoch, M. (2017). Performance improvement of cluster-based routing protocol in VANET. Ieee access, 5, 15354-15371.

Ali, G. M. N., Chong, P. H. J., Samantha, S. K., & Chan, E. (2016). Efficient data dissemination in cooperative multi-RSU vehicular ad hoc networks (VANETs). Journal of Systems and Software, 117, 508-527.

Banani, S., Gordon, S., Thiemjarus, S., & Kittipiyakul, S. (2018). Verifying safety messages using relative-time and zone priority in vehicular ad hoc networks. Sensors, 18(4), 1195.

Bersali, M., Rachedi, A., & Bouarfa, H. (2020, November). A new collaborative clustering approach for the Internet of vehicles (CCA-IoV). In 2020 Second International Conference on Embedded & Distributed Systems (EDiS) (pp. 58-63). IEEE.

Bhabani, B., & Mahapatro, J. (2023). CluRMA: A cluster-based RSU-enabled message aggregation scheme for vehicular ad hoc networks. Vehicular Communications, 39, 100564.

Bilal, M., Munir, E. U., & Ullah, A. (2023). BEMD: Beacon-oriented Emergency Message Dissemination scheme for highways. Ad Hoc Networks, 103095.

Chen, M., An, W., Liu, Y., Dong, C., Xu, X., Han, B., & Zhang, P. (2023). Modeling and Performance Analysis of Single-Server Database Over Quasi-static Rayleigh Fading Channel. IEEE Transactions on Vehicular Technology.

Cheng, X., & Huang, B. (2019). A center-based secure and stable clustering algorithm for VANETs on highways. Wireless communications and mobile computing, 2019.

Deng, T., Wei, S., Liu, X., Zhou, H., & Dong, M. (2022). Distributed resource allocation based on timeslot reservation in high-density VANETs. IEEE Transactions on Vehicular Technology, 71(6), 6586-6595.

Desai, D., El-Ocla, H., & Purohit, S. (2023). Data Dissemination in VANETs Using Particle Swarm Optimization. Sensors, 23(4), 2124.

Elbery, A., Hassanein, H. S., Zorba, N., & Rakha, H. A. (2019, December). VANET-based smart navigation for vehicle crowds: FIFA world cup 2022 case study. In 2019 IEEE Global Communications Conference (GLOBECOM) (pp. 1-6). IEEE.

Galaviz-Mosqueda, A., Morales-Sandoval, M., Villarreal-Reyes, S., Galeana-Zapién, H., Rivera-Rodriguez, R., & Alonso-Arevalo, M. A. (2017). Multi-hop broadcast message dissemination in vehicular ad hoc networks: A security perspective review. International Journal of Distributed Sensor Networks, 13(11), 1550147717741263.

Ghaemi, Y., El-Ocla, H., Yadav, N. R., Madana, M. R., Raju, D. K., Dhanabal, V., & Sheshadri, V. (2021). Intelligent Transport System Using Time Delay-Based Multipath Routing Protocol for Vehicular Ad Hoc Networks. Sensors, 21(22), 7706.

Khatri, N., Lee, S., Mateen, A., & Nam, S. Y. (2023). Event Message Clustering Algorithm For Selection Of Majority Message in VANETs. IEEE Access.

Kumar, R., & Dave, M. (2012). A review of various vanet data dissemination protocols. International Journal of u-and e-Service, Science and Technology, 5(3), 27-44.

Kittipiyakul, S. Verifying Safety Messages Using Relative-Time and Zone Priority in Vehicular Ad Hoc Networks Sam Banani, Steven Gordon, Surapa Thiemjarus and.

Lin, D., Kang, J., Squicciarini, A., Wu, Y., Gurung, S., & Tonguz, O. (2016). MoZo: A moving zone based routing protocol using pure V2V communication in VANETs. IEEE Transactions on Mobile Computing, 16(5), 1357-1370.

Liu, H., Qiu, T., Zhou, X., Chen, C., & Chen, N. (2019). Parking-area-assisted spider-web routing protocol for emergency data in urban VANET. IEEE Transactions on Vehicular Technology, 69(1), 971-982.

Ma, G., Wang, X., Hu, M., Ouyang, W., Chen, X., & Li, Y. (2022). DRL-Based Computation Offloading with Queue Stability for Vehicular-Cloud-Assisted Mobile Edge Computing Systems. IEEE Transactions on Intelligent Vehicles.

Ma, X., & Trivedi, K. S. (2021). SINR-based analysis of IEEE 802.11 p/bd broadcast VANETs for safety services. IEEE Transactions on Network and Service Management, 18(3), 2672-2686

Mukhopadhyay, A., Limitha, B. S., Anusha, R., & Gowthami, V. (2022, October). TCP and Priority Queue based Emergency Data Transmission in VANETs. In 2022 IEEE 3rd Global Conference for Advancement in Technology (GCAT) (pp. 1-6). IEEE.

Ning, H., An, Y., Wei, Y., Wu, N., Mu, C., Cheng, H., & Zhu, C. (2023). Modeling and analysis of traffic warning message dissemination system in VANETs. Vehicular Communications, 39, 100566.

Obaid, M., & Szalay, Z. (2020). A novel model representation framework for cooperative intelligent transport systems. Periodica Polytechnica Transportation Engineering, 48(1), 39-44.

Rashid, S. A., Hamdi, M. M., & Alani, S. (2020, June). An overview on quality of service and data dissemination in VANETs. In 2020 International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA) (pp. 1-5). IEEE.

Ren, M., Zhang, J., Khoukhi, L., Labiod, H., & Vèque, V. (2021). A review of clustering algorithms in VANETs. Annals of Telecommunications, 1-23.

Rivoirard, L., Wahl, M., Sondi, P., Berbineau, M., & Gruyer, D. (2017, July). CBL: A clustering scheme for VANETs. In VEHICULAR 2017-The Sixth International Conference on Advances in Vehicular Systems, Technologies and Applications (pp. 19-25).

Said, D., & Mouftah, H. T. (2019). A novel electric vehicles charging/discharging management protocol based on queuing model. IEEE Transactions on Intelligent Vehicles, 5(1), 100-111.

Selvi, M., & Ramakrishnan, B. (2018, October). An efficient message prioritization and scheduled partitioning technique for emergency message broadcasting in VANET. In 2018 3rd International Conference on Communication and Electronics Systems (ICCES) (pp. 776-781). IEEE.

Senouci, O., Harous, S., & Aliouat, Z. (2020). Survey on vehicular ad hoc networks clustering algorithms: Overview, taxonomy, challenges, and open research issues. International Journal of Communication Systems, 33(11), e4402.

Shah, S. S., Malik, A. W., Rahman, A. U., Iqbal, S., & Khan, S. U. (2019). Time barrier-based emergency message dissemination in vehicular ad-hoc networks. IEEE Access, 7, 16494-16503.

Song, C., Tan, G., Yu, C., Ding, N., & Zhang, F. (2017). APDM: An adaptive multi-priority distributed multichannel MAC protocol for vehicular ad hoc networks in unsaturated conditions. Computer Communications, 104, 119-133.

Sousa, S., Santos, A., Costa, A., Dias, B., Ribeiro, B., Gonçalves, F., ... & Gama, Ó. (2017). A new approach on communications architectures for intelligent transportation systems. Procedia computer science, 110, 320-327.

Taherkhani, N., & Pierre, S. (2016). Prioritizing and scheduling messages for congestion control in vehicular ad hoc networks. Computer Networks, 108, 15-28.

Tang, L., Duan, Z., & Zhu, Y. (2018). Data dissemination in service discovery for vehicular ad hoc networks: a survey. IET Intelligent Transport Systems, 12(10), 1189-1200.

Tseng, H. W., Wu, R. Y., & Lo, C. W. (2020). A stable clustering algorithm using the traffic regularity of buses in urban VANET scenarios. Wireless Networks, 26, 2665-2679.

Wang, Y., Shi, J., & Chen, L. (2023). Performance Analysis of IEEE 802.11 p MAC with Considering Capture Effect under Nakagami-m Fading Channel in VANETs. Entropy, 25(2), 218.

Yang, X., Mao, Y., Xu, Q., & Wang, L. (2022). Priority-based hybrid MAC protocol for VANET with UAV-enabled roadside units. Wireless Communications and Mobile Computing, 2022.

Ye, F., Roy, S., & Wang, H. (2012). Efficient data dissemination in vehicular ad hoc networks. IEEE Journal on Selected Areas in Communications, 30(4), 769-779.

Ye, J., Xiang, L., & Ge, X. (2023). Spatial-Temporal Modeling and Analysis of Reliability and Delay in Urban V2X Networks. IEEE Transactions on Network Science and Engineering.

الخلاصة

في السنوات الأخيرة ، زادت الأبحاث حول أنظمة النقل الذكية (ITS) نظرًا لأهميتها في محاكاة سيناريوهات الحياة الواقعية لتحسين نظام النقل كونه ركيزة أساسية لتوفير التناقل في جميع أنحاء العالم. شبكات المركبات اللاسلكية (VAVET) هي مفهوم آخر لأنظمة النقل الذكية التي تعد امتدادًا للشبكة اللاسلكية. تشكل بنية شبكات المركبات تحديًا بسبب التغيير المستمر في حركة المركبة مع مرور الوقت. من ناحية أخرى ، تتبادل المركبات الرسائل مع بعضها البعض ومع وحدات جانب الطريق للتواصل حول إرشادات الطريق أو المشاكل ، فضلاً عن استخدام التطبيقات المختلفة مثل تطبيقات السلامة والترفيه وغيرها.

تتضمن الرسائل في VANET عدة أنواع ، تصنف الى الرسائل الأمنة والرسائل غير الأمنة، حيث يجب مراعاة توصيل الرسائل الامنة بسرعة قبل باقي الرسائل غير الآمنة ، مثل رسائل السرعة ، وتحديد الموقع ، وغيرها.

في هذه الرسالة تم البحث عن نهج لتوفير وصول الرسائل الامنة بطريقة اسرع قدر الامكان وبعدة مستويات من الالولوية. كذلك تم اقتراح طريقة عنقدة جديدة قائمة على اساس وحدات جانب الطريق (RSU)، حيث تم تقسيم الطريق الى مجموعة مناطق متمثلة بالعناقيد وفي كل عنقود تكون RSU هي اساس (رأس) العنقود. تم تقسيم الرسائل الى ثلاث اقسام حسب درجة الاهمية الى (رسالة طوارئ، رسالة مهمة، رسالة عادية) وتم بناء برتوكول يعمل على مبدأ تقديم الخدمة حسب درجة الاهمية.

اضهرت النتائج الى ان الطريقة المقترحة كانت اكثر استقرارية من ناحية العنقدة كون رأس العنقود ثابت به مقارنة بالبحوث السابقة التي كانت تشير الى بناء عناقيد تكون اكثر استقرارية. كذلك اضهرت النتائج احتمالية اكبر في معالجة الرسائل الطارئة والمهمة بصورة اسرع وافضل من الرسائل الاعتيادية ذات الاهمية الاقل.

جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة بابل
كلية تكنلوجيا المعلومات
قسم شبكات المعلومات

الأولوية في نموذج صفوف الانتظار لتحسين نقل البيانات في شبكات المركبات اللاسلكية

رسالة

مقدمة إلى مجلس كلية تكنولوجيا المعلومات في جامعة بابل كجزء من متطلبات نيل درجة الماجستير في تكنولوجيا المعلومات – شبكات المعلومات

مقدمة من قبل

نبراس عبد الرضا حمد موسى

باشراف

أ.د.سعد طالب حسون الجبوري

١٤٤٣ هـ ٢٠٢٣م