



**THE CONTROL OF TRAFFIC LIGHT BASED ON ARCHITECTURE
OF VANET AND SENSOR DEVICES**

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**THE CONTROL OF TRAFFIC LIGHT BASED ON ARCHITECTURE
OF VANET AND SENSOR DEVICES**

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AYAD NOZAD AL-WINDAWI**

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This is to certify that we have read this thesis and that in our opinion, it is fully adequate, in scope and quality, as a thesis of the degree Master of Science (M.Sc.) in Mathematics and Computer Science – Information Technology Program.


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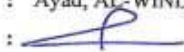
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ABSTRACT

THE CONTROL OF TRAFFIC LIGHT BASED ON ARCHITECTURE OF VANET AND SENSOR DEVICES

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Traffic coordination in streets is a very important and challenging issue. The project gives an adaptive traffic light system based on wireless communication between vehicles and embedded controller nodes existed in intersections and roadside. We have developed an integrated simulation environment. It is discussed that our system can improve traffic fluency in the streets and has clear advantages regarding

performance, time saving and fuel consumption. We have used Intelligent Transportation Systems (ITS) to overcome the road limitation resultants. We are proposing a system design with its protocol and set of algorithms to balance the road traffic load and make the driving on highways and urban cities roads easier and more comfortable. By applying this system on roads, we expect to see an easy traffic flow and more efficient and comfortable driving. Given application results were got from simulation studies, are compared with our system to show the significance or the need for a proposed system with its protocol's control actions and strategies.

Keywords: VANET, Vehicles, Cars, Roads, Traffic, Information, Ad-Hoc, Access Point.

ÖZ

VANET MİMARİSİNE DAYALI TRAFİK IŞIĞI KONTROLÜ VE SENSÖR CİHAZLARI

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Sokaklardaki trafik koordinasyonu çok önemli ve sorunlu bir konudur. Proje; cihazlar ile gömülü kavşaklarda ve yol kenarlarında mevcut gömülü kontrol edici nodlar/devreler arasında telsiz iletişimine dayalı uyarlanabilir bir trafik ışık sistemi sunmaktadır. Bir entegre simülasyon ortamı geliştirmiş bulunuyoruz. Sistemimizin sokaklardaki trafik akışını artırabileceği, bilahare performans, zaman tasarrufu ve yakıt tüketimi itibariyle bariz avantajları olduğu söylenmektedir. Yol sınırlaması ile sonuçlanan hususları aşmak için Akıllı Ulaşım Sistemleri kullandık. Yol trafik yükünü dengelemek ve karayollarında ve şehir içi yollarda daha kolay ve rahat bir sürüş imkanı sağlamak amacıyla protokolü ve algoritma dizi ile birlikte bir sistem tasarımı öneriyoruz. Bu sistemi yollarda uygulamak suretiyle, daha kolay trafik akışı ve daha etkin ve rahat sürüş imkanı görmeyi bekliyoruz. Verilen uygulama sonuçları simülasyon çalışmalarından elde edilmiş ve protokolün kontrol faaliyetleri ve stratejileriyle birlikte önerilen bir sistemin önemini ya da böyle bir sistem duyulan ihtiyacı göstermek üzere bizim sistemimiz ile karşılaştırılmıştır.

Anahtar kelimeler: VANET, Araçlar, Arabalar, Yollar, Trafik, Bilgi Buna Mahsus, Giriş Noktası.

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LIST OF ABBREVIATIONS

VANET Vehicular Ad-Hoc Network
 MN Mobile Network
 SN Sensor Network
 WLAN Wireless Local Area Network
 MANET Mobile Ad-Hoc Networks
 RSU Road Side Unit

AUApplication Unit
OBUOn Board Unit
GPSGlobal PositioningSystem
IDIdentityInformation
EUEuropean Union
ITSIntelligent Transportation Systems
SUB-BSSub Base
MAIN-BSMain Base
GPSRGreedyPerimeterStatelessRoutin

CHAPTER 1

INTRODUCTION

1.1 Introduction to Transportation System and VANET

Traffic congestion is an increasing and serious problem around the world due to the architectural and population expansion, technical development and the great number of cars. The results of traffic congestion are time wasting, fuel consumptions and the environment is harmed by pollutants caused by engines. Far worse than this, the congestion sometimes provokes drivers into a dangerous behaviour, such as running red lights, to compensate lost time. So, this thesis describes how adjusting city's traffic signals can reduce congestion which results in time savings, environmental benefits, and safety [1].

In fact, when the first traffic signal was installed at a Cleveland intersection in 1914, the only objective was to prevent accidents by showing the right way with no interest given to minimize traffic delay, pollution and fuel consumption. Across time, traffic volumes have been increased and the objectives expanded to include maximizing the capacity of the roadways system and improving traffic flow. To go forward in this regard, we have proposed a simulation environment reacting to rush hours which makes connection among cars and with central management as well. Nodes (cars) are connected to exchange data to determine the best path that can be taken to go to their destinations in fast and less consuming way.

Vehicular Ad-Hoc Network (VANET) which is a form of Mobile Ad-Hoc Network is used, in this thesis, to establish short range communications (DSRC) among near Vehicles (V2V Communications) and between vehicles and near existing infrastructure equipment; Roadside equipment (V2I Communications).

Since physical cars have not been used, I have used software Java programming (Eclipse) to

mimic myproposed work. Thereason why the simulation

environment is developed is to design smart management traffic light system for anentire city.

The traffic light management system uses Vehicle Ad-Hoc Network protocol and Vehicle with Infrastructure devices. Applying VANET techniques in real life leads to:

- Reducing the production of Co2 and the consumption of the fuel.
- Enhancing the safety and comfortability for the drivers.
- Reducing air pollutions

So, the used system represents an approach that describes a spontaneous Ad-Hoc network which is formed over moving vehicle through the roads. The vehicular networks are continuously appearing, improving and developing. These are used for a new and traditional application.

The characteristics of these networks include: changing topology, high mobility, and ephemeral, one-time interaction. In Figure 1 shows the vehicular Ad-Hoc network clearly [2].

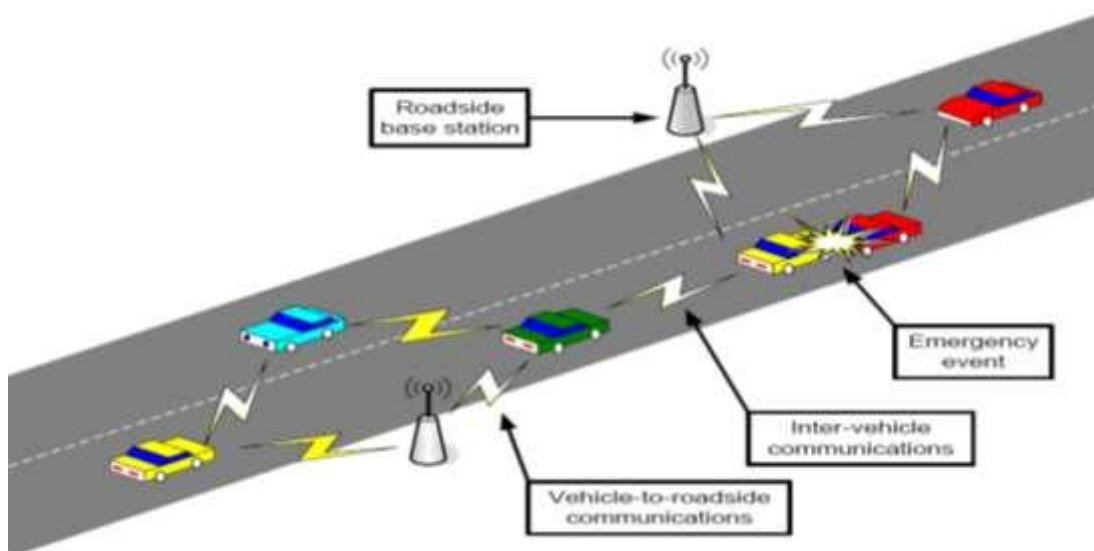


Figure 1 Vehicular Ad-Hoc network

Another important term in this thesis is smart vehicle which is a vehicle that

is equipped with sensors and computers. The numbers of smart vehicles are increasing for the efficient transport, the management applications focused on optimized flows of vehicles by reducing the time that is taken to travel and avoid any traffic congestion in the roads.

1.2 Thesis Organization

This study develops a simulation environment which is an adaptive on short- wireless communication range between the cars (Vehicles V2V and V2I). Starting with an introduction about VANET and moving forward to the background theory, this study aims to manage traffic light in short range communication. The study uses many algorithms with results. There are six chapters in this thesis. Chapter one contains an introduction to VANET and some other terms. Chapter two includes background theory. In chapter three a literature review of many similar or adjacent works is given and compared. Chapter four includes methods and experiment with goals and objectives. Chapter five includes the experiment results. Finally, the conclusion and future are mentioned in chapter six.

1.3 Smart Vehicles

From the very beginning of the artificial intelligence, there had been attempts for using a totally automated intelligent vehicle. Many experiments have been done and some of them ended with fruitful results. As a result for what had been done we have intelligent smart cars. These cars are intelligent and are capable of taking some of the decisions and they actually assist the drivers since they are totally automated. We can say that a fully automated transportation can only be possible through having a group of intelligent vehicles, the developed traffic system and the environments are very essential for this kind of transportation. So, smart vehicles are those vehicles that are equipped with sensors and computers. At any time, the radar that is presented on the on-board could be used to sense the traffic congestion and automatically make the vehicle to be more slowly. In any other accidents warnings systems, the sensors can be used to show that the crash may be occurred if the airbags were deployed; this type of information is relayed then via V2I or V2V within the used vehicular network.

The different levels of functionality are provided by using number of systems and sensors which includes:

- The crash sensors
- The data recorder.
- The braking system.
- The engine control unit.
- The electronic stability control.
- The information system.
- The integrated starter generator.
- The electronic steering.
- The tire pressure monitoring system.
- The power distribution and connectivity.
- The lighting system, seatbelt sensors.

In the braking systems, there are also the anti-lock brakes system and the parking brake system.

The parking brake is referred also to an emergency brake; it is used to control the rear brakes by using a series of steel wires (steel cables). By using this parking brake, it is possible to make the vehicle stopped when a sudden failure occurs for the event of a total brake. The cameras which are mounted with the vehicles are mainly used to display images on the vehicle console of smart vehicle [2] (As in figures 2).

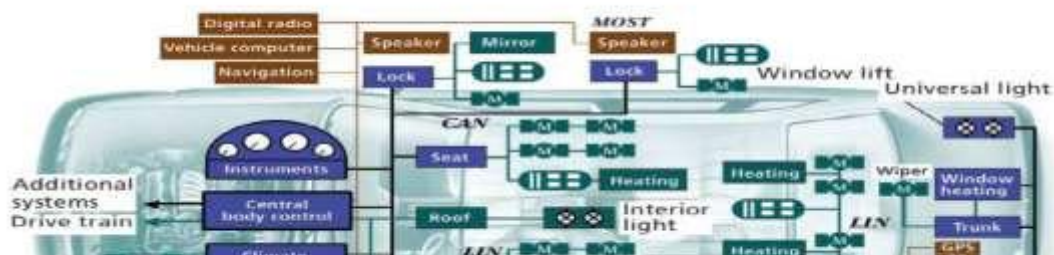


Figure 2 Smart vehicle systems

In this thesis work, we proposed a project by using a VANET-V2I and Sensor Network (SN) that is used to calculate information of the road and send the data to a special unit named data controlling central. In this project, the VANET is employed to make connection through the collected traffic data from the road for the traffic light controller to manage the traffic light phasing, manage the timing and making the traffic flow more easily.

CHAPTER 2

BACKGROUND THEORY

2.1 Infrastructure Wireless Communication

WLANs are very important in every infrastructure network. The infrastructure network is not providing access to the ether network only, but they also include functions for forwarding, medium access control and etc. In these based wireless infrastructure networks, typically the communication takes place between the nodes of wireless and the access point only, but not directly between the nodes of wireless [3]. (As in figure 3),

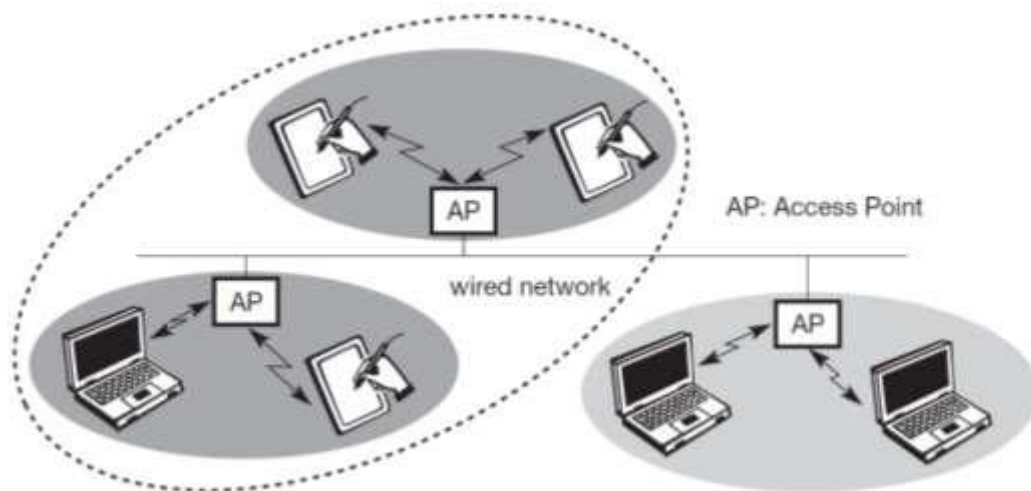


Figure 3 Infrastructure wireless network

The access point doesn't control the medium access immediately, but they act as a bridge also to other wireless or wired types networks. Figure 3 that shows three access points or nodes including their three wireless network types and also a wired network type. Many wireless networks may have a form of a logical wireless network. Thus, the access points with the fixed network together in between can connect several wireless networks in order to build a large network behind

the actual coverage of the radio. Usually, the infrastructure wireless based on network design is very simple because most of the networks have functions working within the access point region, while the clients of the wireless can stay very simple. This structure is reminiscent of switched Ethernet or other forms of the star-based networks, where an element in the centre (as a switch) will control the network flow. Different access schemes can be used by this kind of network with or without a collision. The collisions may be occurred if the medium access of the wireless nodes and the access point are not arranged. So, if the access point only control the medium access, collisions are impossible to happen. This setting can be useful for the quality of the service guarantee such as the bandwidth of minimum for the certain nodes. The access point cannot be as a single wireless node to insure the data rate [3].

2.2 AD-Hoc Wireless Communication

The Ad-Hoc wireless networks do not need any infrastructure to work. Every node can communicate with other nodes directly, thus, it is not necessary for the access point to control the medium access. Figure 4 shows the two networks of ad-hoc with three nodes for each one. The nodes which are inside the ad-hoc network that can be communicated only if they physically can reach one another, for example if they are overlapped with their radio range or if the message can be forwarded by other nodes. The nodes shown in Figure 4 can be communicated only with each other if they are in the same range of the radio. In head-hoc networks, a high complexity is there for each node because medium access mechanisms have to be implemented by every node, the mechanisms to handle the hidden or exposed problems of the terminal and probably priority mechanisms, to provide a service with a certain quality. This kind of wireless network is flexible that exhibited the greatest possibility as it is, as an example, an unexpected meeting that is needed, prompt communication scenarios or replacement of infrastructure is very far from any network of the infrastructure type [3].

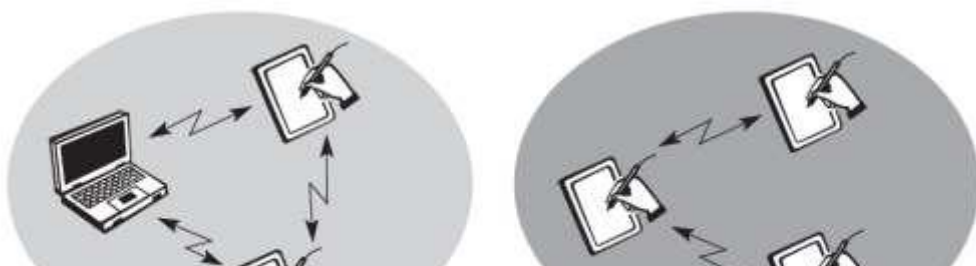


Figure 4 Ad-Hoc wireless network

2.3 Mobile Ad-Hoc Networks (MANET)

The mobile Ad-Hoc networks are very flexible wireless networks that do not rely on any external infrastructure like routers or radio towers. The network is built by the nodes themselves, and usually the messages are sent using multi-hop routing in which the nodes of the network act as routers to deliver messages outside of the sender's transmission range. The basic challenge for building a MANET is for each device to maintain the required information continuously to route traffic properly. Each node of the MANET may be able to move independently in a manner that is not necessarily predictable by other nodes [4].

2.4 Vehicular Ad-Hoc Network (VANET)

Many manufacturers of the cars in these research institutions investigate many ways for the vehicular networks establishing. They represent an attractive solution for inter-vehicular communications because of the flexible nature of the Mobile Ad-Hoc Networks (MANET) [5, 6].

VANETs have many unique characteristics that are not shared by other types of MANETs and according to the following:

- a. The vehicles move at a high speed.
- b. Patterns of the mobility are predictable sometimes as a constrained movement by road infrastructure. In some situations like the highway traffic, the mobility patterns become highly predictable.
- c. Large coverage area. Here the vehicles are travelled over long distances with a traffic information that maybe useful to vehicles in hundreds of miles away.
- d. Power consumption is not a major concern. Vehicles are mobile power plants.
- e. The Vehicles have a high cost and therefore can be equipped with additional

sensors without significantly impacting the total cost.

f. The VANET's topology is dynamic extremely like the vehicle that go in and out transmission range quite rapidly.

g. The Vehicle travel long distances in a small time amount when compared with other mobile networks.

2.5 VANET Architecture

Communication among the vehicles and the Road Side Unit (RSU) or among vehicles with each other can be established by a wireless medium known as "wave".

This communication approach has the ability to provide drivers and travellers with a wider range of information and safety applications which support the safety of the streets and give more comfortable driving.

The main system consists of the following components: the application unit (AU), on board unit (OBU), and road side unit (RSU).

1- Road Side Unit (RSU) hosts application which has services.

2- On Board Unit (OBU) is a poor device which uses the delivered application services.

3 - Application Unit (AU) can be resided either in OBU or in RSU.

This application is hosted on a device that is called the provider and the term user describes the device using the application.

Vehicles in the system are equipped with a set of sensors and OBU for the favour of data collecting and data processing operations, before sending the packet of data to RSU or other vehicles via the wireless medium. Furthermore, it can be one or more AU to be used by the provider regarding the on board unit connection facilities and capabilities. Also RSU might be connected directly to the internet or to a specific server which connects the application units (AUs) of other vehicle together with the internet [7, 8].

2.6 On Board Unit (OBU)

This unit is a wave device or vehicle based on the onboard which exchanges the data with other devices or RSUs. A typical OBU consists of a resource command processor (RCP), along with other resources such as: redrigh memory, user interface, interface that connects OBUs together and a short range wireless device for communication (i.e. IEEE 802.11 P radio technology). This wireless device connects OBU to other OBUs or to RSU by using IEEE 802.11 P radio channel. Additionally, it supports services of communication to AU, and broadcasting the data to its destination. The main tasks of OBU are ad-hoc network congestion control, wireless access, geographical routing, data security, transfer messages reliably, and IP mobility [9].

2.7 Application Unit (AU)

This device is equipped in the vehicles that use the provided applications by the provider through communication service of OBU.

AU device can be used either as a dedicated device (e.g. in safety applications) or as a normal device (e.g. personal digital assistant PDA). AU connection to the OBU could be wired or wireless manner. Also it could be beside the OBU in one single unit, as the destination between OBU and AU is logical. AU can only reach the internet through OBU [7, 9].

2.8 Road Side Unit (RSU)

This unit is a wave device that is fixed on the road on specific locations such as: parking spaces, squares, and junctions. RSU could be equipped with a single network device (i.e. based on IEEE 802.11 P). Furthermore, it could be equipped with other network devices in order to be used for communication in the network infrastructures. (Figures 5-6-7).

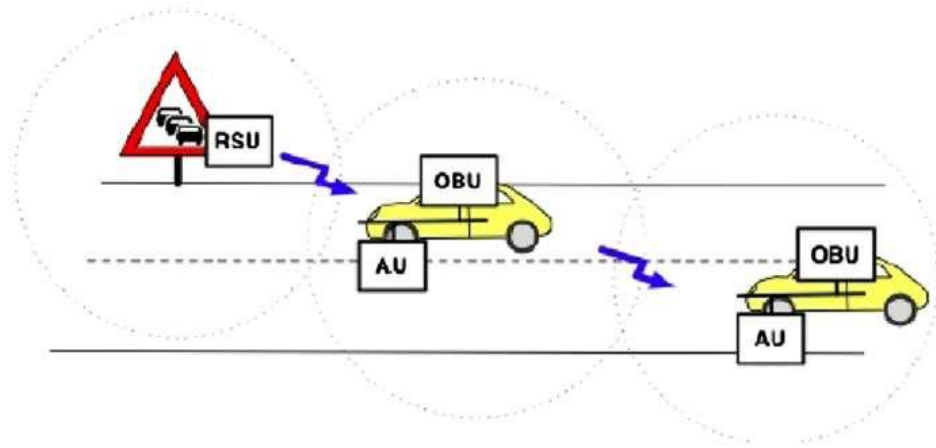


Figure5 RSU works as information source (running the safety applications)

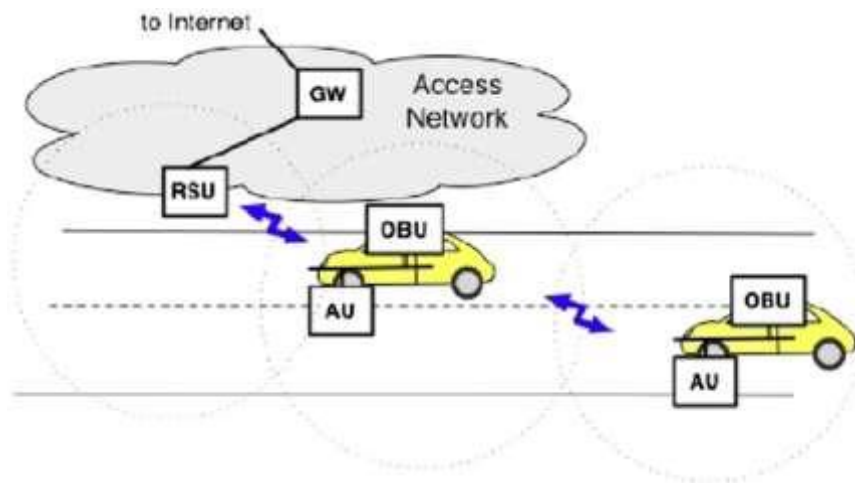


Figure6 RSU provides internet connectivity to the OBUs

According to Figure (7), the main task and procedure of RSU can be summarized as:

- 1- Expanding the communication range of the ad-hoc network (i.e. Redistribution of the data to OBUs and sends the data to other RSUs for the favour of resending it to other OBUs.
- 2- Executing safety applications such as accident warning and low bridge warning, using the infrastructure vehicle (I2V) technique, and routing as a source of data.
- 3- Providing internet connectivity to OBUs

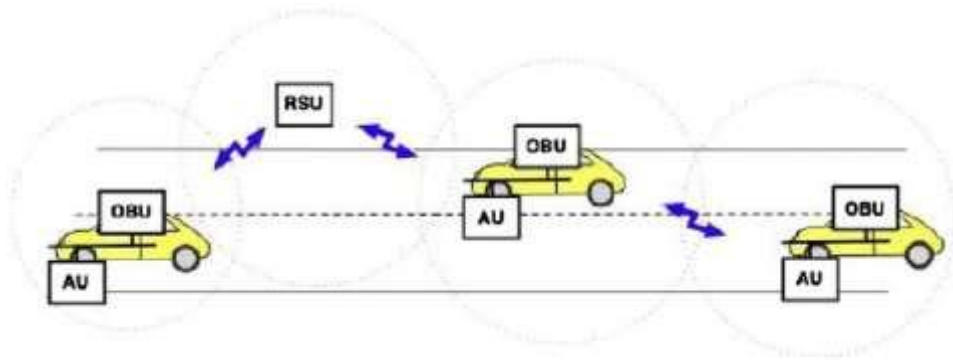


Figure 7 RSU extends the range of the Ad Hoc network by forwarding the data of OBUs

CHAPTER 3

LITERATURE REVIEW

Many researches of VANET have focused on simulating vehicular traffic and multi-hop routing. Few researches have studied the problem of using VANETs for the purpose of discovering the traffic congestion. Using the vehicles that are based on the VANET systems can create Ad-Hoc wireless network that can be used to find and publicize the traffic congestion information. Since many years ago, the issue of the distributed detection, the traffic congestion and the information propagation has been addressed by several researchers. Fukumoto et al [16] proposed a system that uses vehicle based GPS system to discover and disseminate traffic congestion information. The system is called COC that uses VANET. This system maintains and disseminates three types of information: Raw Information (level 1), density information (level 2) and congestion areas information (level 3). Higher levels contain aggregated information. In [17], Donbush, et al proposed a novel system for congestion detection in VANET. SmartStreet which uses the clustering as a technique for the data aggregation to combine the unusual related data that has a low speed. SmartStreet uses the clustered algorithm that work over a distributed network in which every node investigates the collected statistics and eliminating the need for a central entity. The clustering operation can be defined as a combination process that contains data points; these points have a similarity one to each other that use many measure types. In [19], Yoon, Noble and Li proposed a system for traffic estimation that is based on road segmentation and focused on the complex inner-city. Some of these systems rely, either explicitly or implicitly, on having the location for all vehicles in the available congestion in order to make the determination that the congestion exists and where it is located. When congestion sizes exceed transmission ranges, that are common in freeway scenarios, the use of multi-hop communications are required in an order

that represents all vehicles in the

congestion to have knowledge of all other vehicles in the congestion. This presents a problem if we want to keep location information anonymous; a vehicle may receive fresh information directly from a vehicle and re-broadcasted information (older) from the same vehicle. Because of the vehicles constantly movable, these two pieces of information will be indistinguishable from the two pieces referring to the two vehicles different from one to each other. Because of this reason, these systems rely on unique vehicle IDs as a mechanism to identify the source of each one of these pieces of information and maintain a unique location for each one of these vehicles. The broadcasting of unique vehicle ID's at the application level opens the door for the location purpose of the tracking raising major privacy concerns. Most of the recently companies realize the potentials of using these vehicles as collectors of the traffic information, Dash Navigation, Inc. [20] a start-up in Sunny Valley, CA started service offering in 2009 which is called the Dash Driver Network that makes the passengers able to broadcast the location using a high speed depending on exchanging operations to receive the information of the updated traffic that is obtained from other vehicles in the network. This system is centralized and relies on wireless connectivity of the internet which is widely unavailable on the streets and the highways roads around the world. The trusted location, privacy concerns are mitigated due to the centrality of the collecting entry.

The CAR 2 CAR communication (two cars communication) Consortium [21] is an organization that is non-profit initiating by the manufacturers Western vehicle that has an objective which is used to enhance the safety traffic's road, the efficient publishing in 2007 a manifesto that is proposed as standards for V2I and V2V communications through many things. The other organizations [30] are obtained from the industry, the universities and the governments which have started similar efforts in the last many years.

In 2008, the European Union took a major first step towards deployment of the systems that are relying on the V2I and V2V communications by doing new reserved operations for the radio frequency across the EU that is used for the applications of the vehicle used at the co-operative enabled systems between the makers' car [22]. The EU looks forward through this action that leads to the eventual roll-9.

CHAPTER 4

METHOD AND EXPERIMENTS

4.1 Introduction

The (ITS) Intelligent Transportation Systems is mostly used to solve the road limitations. In this thesis we proposed a system design including a protocol and many algorithms that assist to balance the traffic of the road and to facilitate the driving on the urban cities and the highway roads and make it more comfortable. The system contains some basic devices. These devices would cooperate together to provide the safety, assistance, and to make the passengers (drivers) more comfortable. Whenever we use this system on streets, we expect to see an easy flow for the traffic and more efficient and driving that is very comfortable.

The selected results of the application are gotten from the studies of the simulation. These results are compared with our system to prove that the significance or the need for the presented system with its control actions of the protocol and its strategies.

4.2 Goals and Objectives

The main objectives of this project are to implement the protocol on a vehicle inside the protocol creation in order to get the data processing which is collected in the first objective. The writing operation of the algorithm that makes an optimum decision for the plan of the phase of the traffic light, is another goal. Inside these objectives we can manage the city traffic network and also decrease the fuel consumption and time taken by the driver to go to their destination. Also reducing the production of CO₂.

To go forward and to get advantages of the researches done on VANET applications, are the main factors that motivated us in order to propose the protocol. In their efforts to enhance the driving safety and the comfort-ability, the manufactures of

these cars manufactures are waiting for new technologies and applications to be made in order to use with their products. The protocol of our system is very important and suitable to use by other applications in future works. Due to the increasing air pollution, new methods and technologies are needed for sudden urgent to reduce this problem. To make traffic flow working easily at intersections, the vehicles have not to let stopped for a long time at the traffic light points. Many technologies and methods can be used to control the vehicles movement and store their information continuously by using this VANET system in roads, main gates and cities.

4.3 System Design and Implementations

As we have proposed in first chapter that we are going to design a smart management traffic light system for an entire city. The traffic light management system is using Vehicle Ad-Hoc Network protocol and Vehicle to Infrastructure (VANET-V2I); these receipts are employed to help in collecting traffic data from the roads and streets by accounting each car embedded by a mobile device support VANET connection; then forwarding the collected data to the local base station. Then the management system will take the best decision of traffic managing.

4.3.1 Infrastructuredesign

1. We have assumed that each or most of the vehicles (cars) of the city have a mobile device which is working on VANET protocol for sending and receiving information with recipient devices with a unique ID.
2. To distribute recipient devices within regular spaces; we use Omni antenna [23].
3. Each area that has a station is called sub base station (SUB-BS).
4. The recipients of each area are connected by SUB-BS.
5. All of the SUB-BSs are connected to the main base station MAIN-BS.
6. The MAIN-BS is consisted of: Omni antenna, Database centre and processor which are responsible to get decision for traffic light controlling by calculating the rates of cars per each street.

Figure 8 illustrates the distribution and the hierarchy of the system modules. Figure 9 shows the interaction between units.

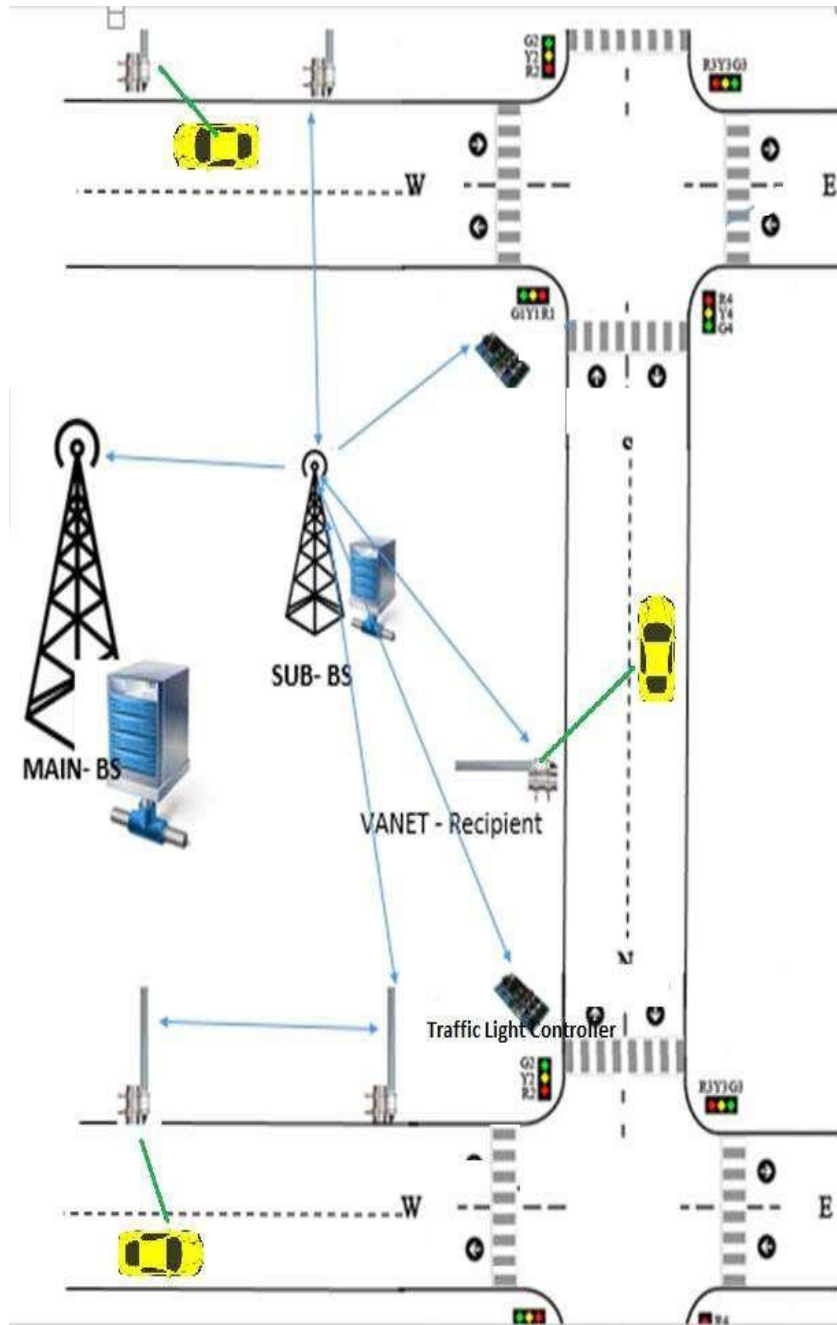


Figure8Overall system

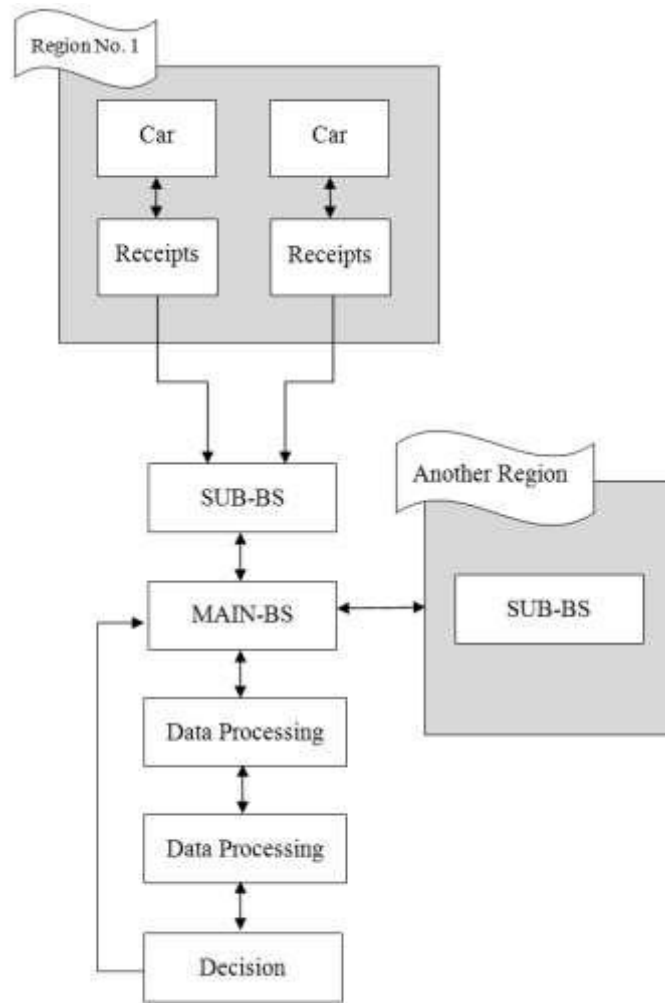


Figure 9 Flowchart of units interaction

We got street information and the number of cars through existing sub-based stations. Then according to certain data the main base station will make the decision then resend it to the sub-base station to do what is required.

4.4 System Scenario

4.4.1 VANET connection

1. Cars with VANET mobile device is periodically broadcasting a HELLO message which include the unique ID. We have used Greedy Perimeter Stateless Routing (GPSR) protocol for network layer in VANET.

2. When the recipients get a message with a new ID, it will be transmitted to the Sub-BS but when the message is the same, it will be discarded.

3. Sub-BS periodically will be forwarding the number of cars passed the way per that moment.

4. Main-BS will calculate the density of cars flow on that time for each street then it will take the best decision. In our project we have assumed that the capacity of all the roads are the same so that the decision will be taken depend on the car rate only without taking into account the capacity of roads as shown in the following Figure.

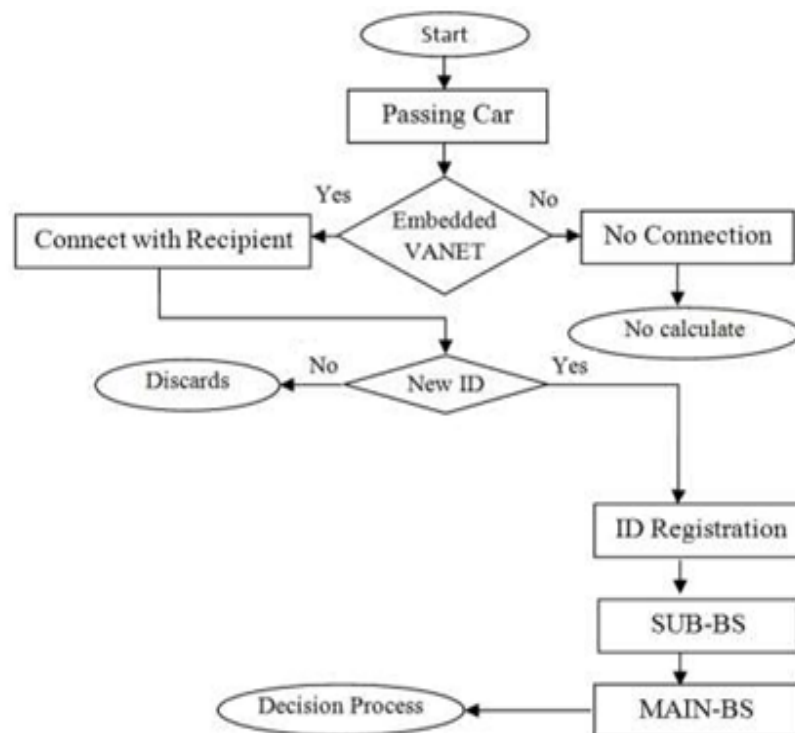


Figure 10 Flowchart of connection steps

After we get the number of the cars passing on the streets, we make an inquiry about whether the car entering is old or a new one. If it is new, it will be given ID. The inquiry will be sent to the sub-station and the same will be for the other cars. The inquiry also can be sent from the sub-base station existed in other streets to the main base station.

After getting full information from sub-base station, process can be made through certain processors. Then, decision will be made according to what is planned. Finally the decision will be sent to a certain station and resend it to the cars so that the driver can do what is necessary.

4.4.2 Central traffic light management (CTLM)

1- The central traffic light management, which we have proposed, is the main computer that is connected with the "MAIN-BASE STATION".

2- The Main-BS includes database management centre which contains the gathered data brought by SUB-BS.

3- We assume, in our project, that all streets with same capacity so that the decision will be easier.

4- We would apply our system on few number of roads (streets).

5- The decision should be taken depending on the number of cars for each street as the following:

a. When the number of cars are not exceeded the threshold value, the time will be the same with no change.

b. When the number of cars is exceeding the first threshold value but not the second threshold value, the time of GREEN will be increased.

c. When the number of cars is exceeding the first threshold, and second threshold values, the time of GREEN will be increased, and the time of RED will be decreased.

The following flowchart is showing steps of the central traffic light management decisions.

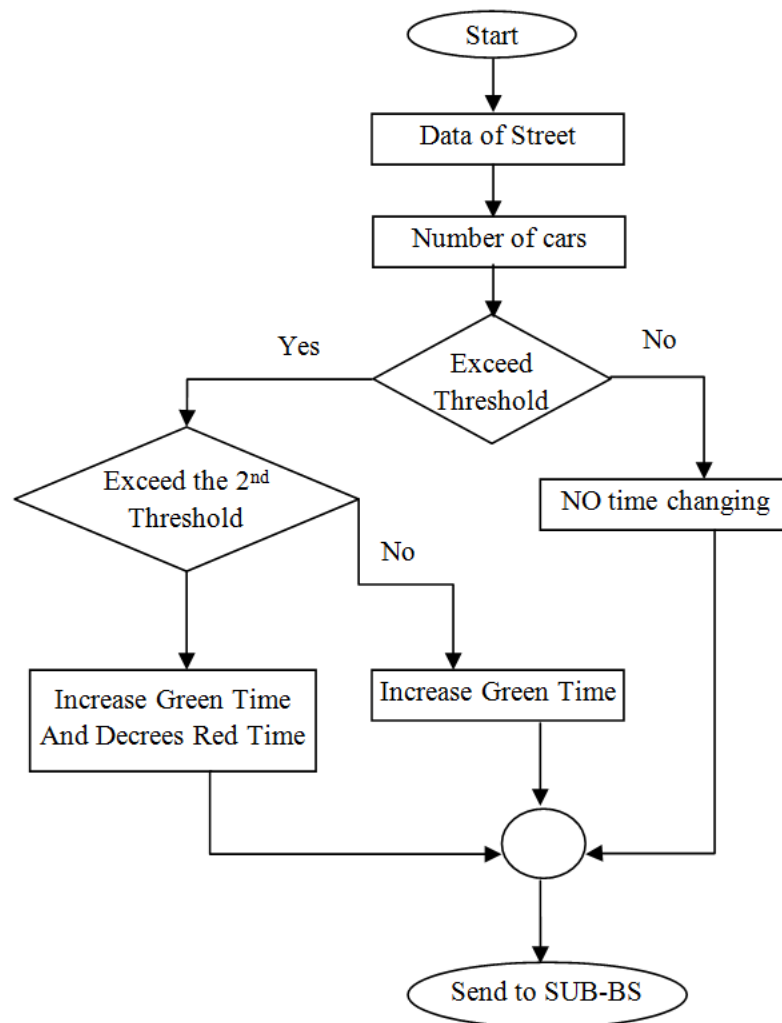


Figure 11 Flowchart of the central traffic light management decision

In this algorithm, we divide the congestion into two types: the normal and severe one. Whenever the number of cars is increased from the first level that we put in the algorithm, we will increase the time of green signal and if it does not exceed the first level, no time changing will be seen. If it is exceeded the second level which is considered as severe one, we increase the time of green signal and decrease the red one.

CHAPTER 5

EXPERIMENT RESULTS

5.1 The Implementation of Modules

In our thesis, the Java environment is used to implement the work, Java platform enterprise edition (Java EE), which is used here, is the standard in community driven enterprise software. The Java EE is developed by using the Java community process, with contributions given by the experts, the open source and the commercial organizations. The purpose of using this environment is because of its flexibility and high security. It is used mostly to increase the developer productivity, The implementation of our work is done in three steps (modules) as following:

1. **The first module.** The main objective of this module is to study, design and implement the system (on car or vehicle and on the street devices) to create and collect data from streets and the objects on that streets. Further purpose is the protocol creation for the data processing that has been collected and applied.

2. **The second module:** Throughout this module, our main objective will be the writing of an algorithm for creating an optimum decision for the plan of the traffic light phase to control the traffic and to make the decision for traffic signal. The reduction of CO₂ production and the fuel consumption is considered as a final objective.

3. **The third module:** In this module we are creating performance evaluations of the project throughout graphs. i.e.

- The average of waiting time for the vehicles.
- The number of passed vehicles.
- The number of cars reaching their destinations; Adaptive Traffic Lights.
- The average control delay for the simulated period.
- The average of fuel consumption

5.2 Project Interfaces

Regulatory traffic signs play a critical role in road transportation since they provide information that drivers must follow to ensure road safety and improve traffic control. Replacing the traditional traffic lights by virtual traffic lights, is probably the most challenging situation where virtual traffic signs can be applied, we have chosen a number of different scenarios where virtual traffic lights can be tested. In fact, virtual traffic lights can be placed not only at intersections, but in a variety of environments where the crossing conflicts need to be solved.

Traffic light intersection is managed by the main processing centre, which is connected by the main base station. The main processing centre gets data from the sub-base stations as is shown in the Figure 12. Returning back how long times should be given to the particular intersection traffic light controller. Figure 12 represents the first module of the system which developed ten main streets and eight traffic light intersection controllers and three base stations. All these base stations are connected within one main base station, as shown in the Figure 12. The time of traffic lights is not fixed, but it changes according to the congestion of the way.

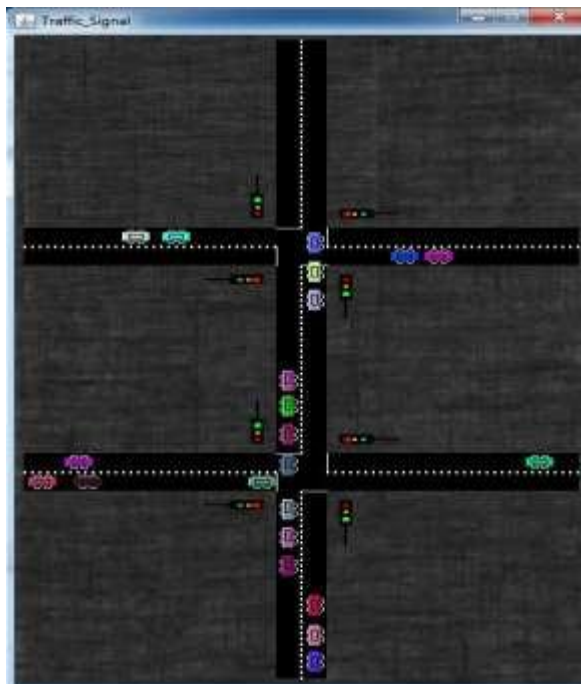


Figure 12 Traffic light intersection

This helps to regulate and control conflicts between vehicles in different lanes, improving the traffic efficiency and safety in the only lane available.

The second model we have made more than 10 nodes (cars) moving on the paths (roads) in a random manner to get several results as shown in (Figure 13). There are many thresholds used according to the cases. The first threshold value (no of cars greater or equal) has assigned five cars at an instance in a particular intersection. Where the second threshold has assigned seven cars at an instance in a particular intersection.

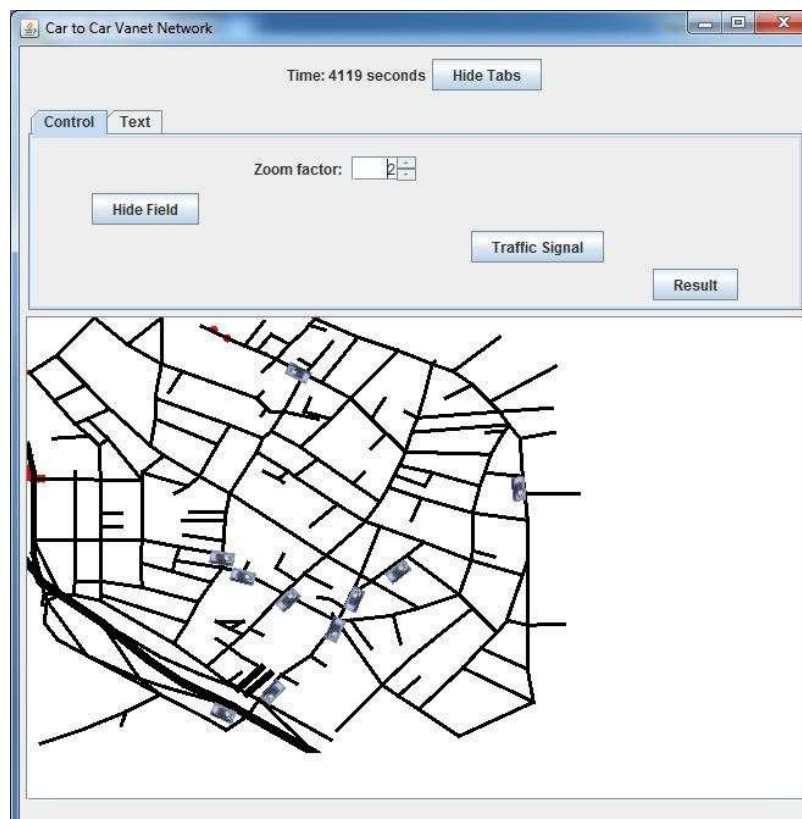


Figure 13 Ten main streets and ten traffic light intersection controllers

When the number of cars reaches the first threshold, the processing centre will increase the green light value depending on the road class number (1, 2, 3, 4, 5, 6) by 0.25, 0.27, 0.29, 0.29, 0.3, and 0.3 seconds respectively. But when it increases the second threshold value, the processing centre will increase the green light by same second values as well as decreasing the red value by the green light through value depends on the road class number (1, 2, 3, 4, 5, 6) by (0.25, 0.27, 0.29, 0.29, and 0.3) seconds respectively.

Threshold value is changing dynamically; it depends on the number of cars in the street that increases and reduces the congestion of cars in the street. So, it can be said that threshold value is changeable according to the number of cars. If there are four cars in street A and five in street B, threshold value will be changed according to the number of cars in street A and B and the timing of traffic light changing, from green to red or from red to green, will be changed accordingly.

Generally speaking, in any dynamic environment such as VANETs, it is difficult to determine these threshold values since they are changing dynamically. The reason behind this dynamic change of the values is because they minimize the number of redundant messages during keeping good latency and reachability. The back lines (roads) are shown in Figure 14.



Figure 14 Ten moving nodes

The information of each road can be shown from the (text) button as well as the exchange of data packet details are shown in the following Figure (15). The green bar that is shown in the Figure below shows the path that the car aims to go. At the entire road, the vehicle sends and receives messages from the cars in around to prevent collision and congestion and this is done by slowing down vehicle speed and stops it if it is possible. The area around the vehicle is shown in Figure (15). This area is represented by a circle

around the vehicle, through this range the vehicle could contact, send messages from other vehicles.

and receive

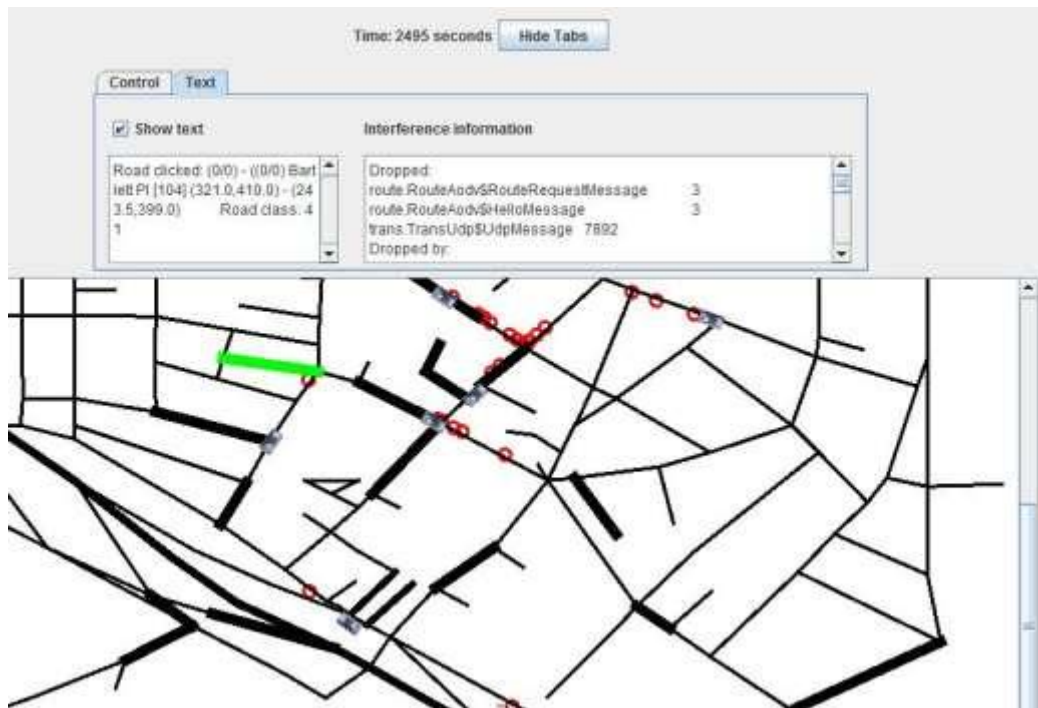


Figure15 Interference information

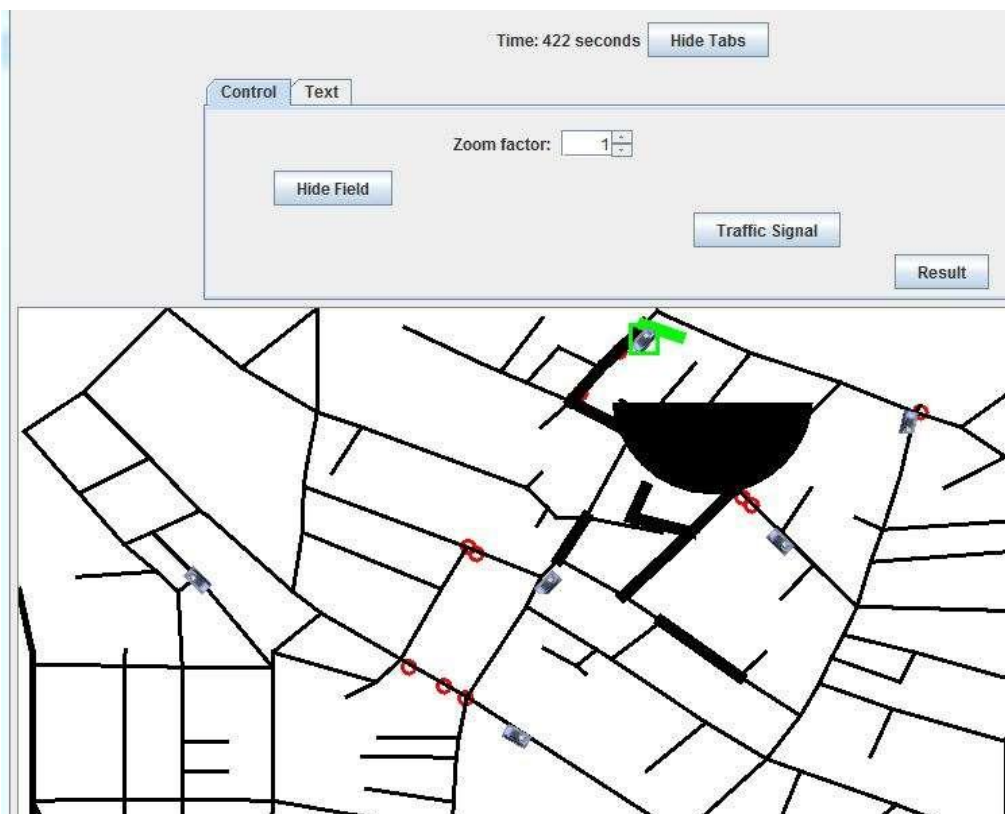


Figure16 Searching area around the vehicle

We have made our design to select a particular car to be interacted with the data processing centre to give it the shortest path (with minimum congestion). As it is shown in Figure (17). We have compared the results of four algorithms with blue colour, fixed time algorithm to be with green colour and the DT3P algorithm with red colour as in the following:

1. The average of the waiting time for the cars in the same scenario within 50 seconds has decreased the spent time doing the same scenario compared with the others as shown in the algorithm.

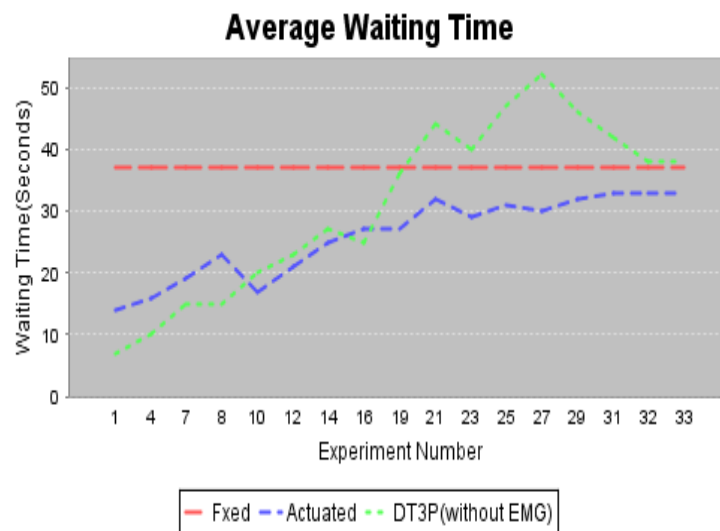


Figure 17 Average of waiting time

2. Total number of passed cars per hour in 31 tries. Figure 18 shows the representation of these passed cars.

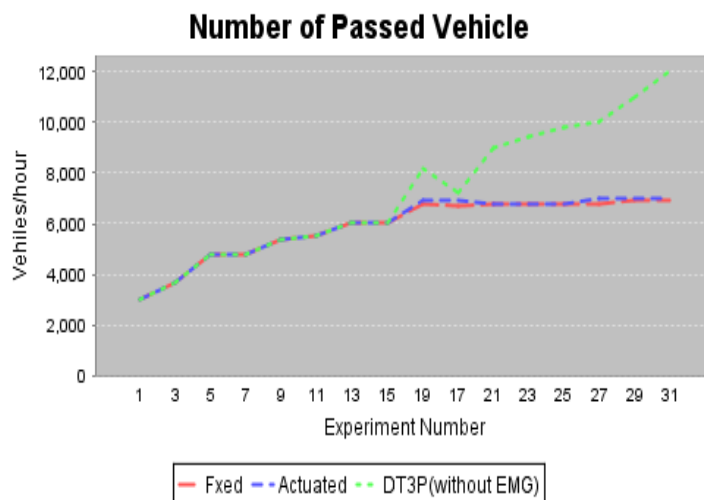


Figure 18 Number of passed cars per hours

3. Average fuel consumption depends on the average waiting time for cars, as in the following Figure (19). All the shortest path, the dynamic path (routing week 1) and the dynamic path (routing week 2) have very adjacent time values. The given results from week 1 and week 2 dynamic routing are similar with a small difference from the shortest path.

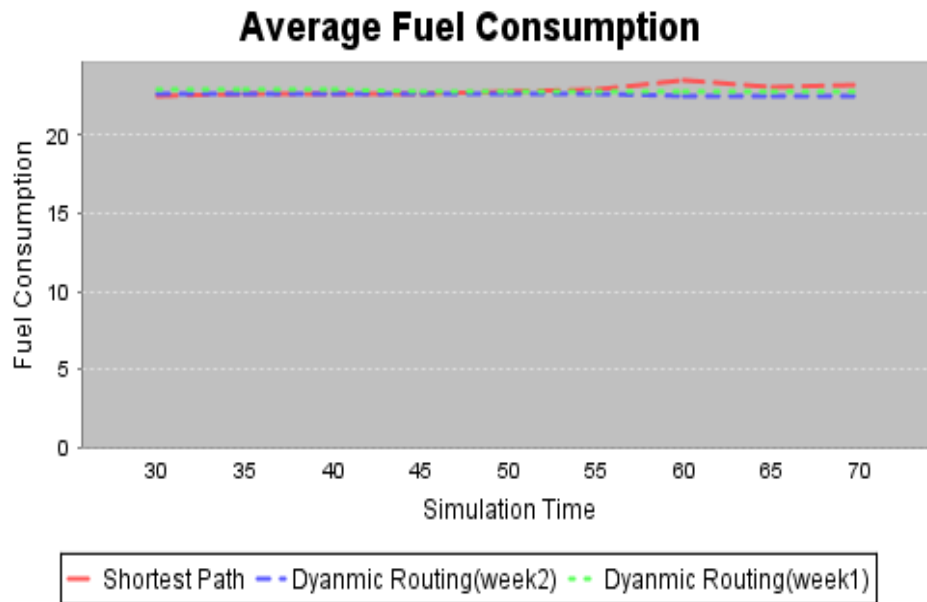


Figure 19 Average fuel consumption

4. The average delay time for cars during used simulation, as it is shown in Figure (20), includes three representations (Pre-timed, Adaptive Ideal, Adaptive-Real). The given results remain similar from the beginning up to the 65 minutes. After this time the adaptive real remains similar to the Pre-timed until the 75 minutes. Then it begins to differ, while the adaptive real is different to both the adaptive ideal and the Pre-timed from the 75 minutes to the end of the period.

Average Control Delay for the simulated period during the scenario

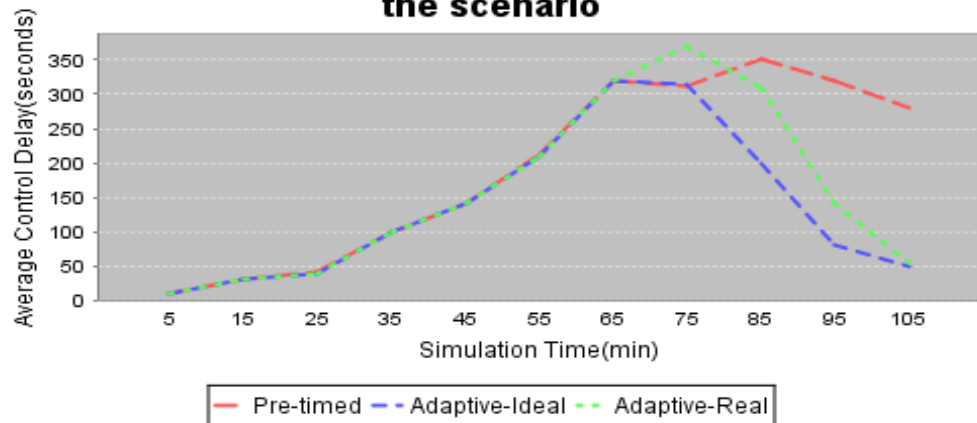


Figure20 Averaged delay time

The number of cars that reach the destinations by using our algorithm is in green colour and without using the blue colour. Figure (21) shows the histogram that represents the needed time to reach the target from the instant including the shortest paths and the dynamic routing. Although there is a small difference between the dynamic routing and the shortest used path by the cars but they are still very adjacent to each other. Thus, it has a high quality to reach the actual time values.

No. Of cars reaching their destinations: Adaptive Traffic Lights

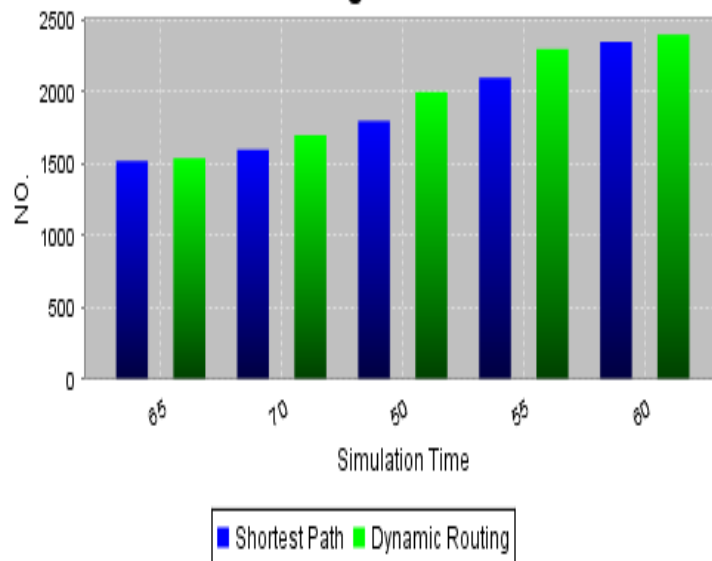


Figure21 Numbers of cars reaching destinations

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

We have based a traffic light system that is very adaptive on the short-wireless communication range between cars and infrastructure. The system rests on a node of wireless controller that is situated at the intersection. It specifies the exacted amounts (value) for the phases of the traffic lights. We have improved also a simulator that is integrated for validating the system.

The framework of the simulation consists of a model with a real mobility model for cars or vehicles and a simulator of a wireless network. We have dealt with two major intersections in many places and we have seen that the system significantly develops traffic fluency, compared to the existing. It has been designed as an analysable actions system for rush hours and we have got acceptable results. The averaged delay, fuel consumption and the pollution were tremendously decreased.

6.2 Future Work

Our project has been done on a simulation environment. Thus, the result is not occurred so we suggest doing this project on a real time environment. We suggest to optimize the security of the VANET network as this system should be worked in a very high secure and reliable environment. Also, we suggest enhancing the routing protocol algorithm which has direct effects. Finally, it can contain many application benefits for the last users such as trading announcements and so on.

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APPENDICES A

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