Scheduling and Optimization of Traffic Lights In VANET

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By

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Undertaking for originality of the work

I, **Zarana R. Shah**, **11MCEC53**, give undertaking that the Major Project entitled **"Scheduling and Optimization of Traffic Lights In VANET"** submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in Institute of Technology of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

Zarana R Shah(11MCEC53)
Date: May 20, 2014
Place: Ahmedabad

Certificate

This is to certify that the Major Project entitled "Scheduling and Optimization of Traffic Lights In VANET" submitted by Shah Zarana R.(11MCEC53), towards the partial fulfillment of the requirements for the degree of Master of Technology in Computer Science and Engineering of Nirma University, Ahmedabad is the record of work carried out by her under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Abstract

With the advent of various advances in vehicles, traffic congestion is a serious problem in big cities. With the number of vehicles increasing rapidly, especially in cities, the situation is getting even worse. Traffic lights are used to control the flow of traffic, which can help peoples to reach their destination without any unnecessary delay of traffic Congestion at cross road. Currently, fixed cycle traffic light system manages traffic, throughput of traffic decreases at intersections during rush hours. Hence, an Adaptive traffic light scheduling system is proposed here. This system dynamically changes the cycle of traffic lights according to current traffic, and even the scheduling scheme is modified for avoiding unnecessary delay. Advances of Vehicles led to vehicular communication through Vehicular Ad hoc Network (VANET). Communication between Vehicle to Vehicle and Vehicle to Infrastructure is now possible. In this proposed approach, real-time speed and position information is aggregated from individual vehicles to improve traffic flow at intersections (crossroads), so that, vehicle can travel with minimum delay. Various scheduling algorithms are compared with respect to platoons of vehicles. The main goal is to reduce average delay, fuel consumption and air pollution. This would eventually reduce the Drivers Fatigue.

Acknowledgements

A journey is easier when you travel together. Interdependence is certainly more valuable than independence. This report is the result of work whereby I have been accompanied and supported by many people.

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Abbreviation Notation and Nomenclature

VANET .... Vehicular Ad-hoc NETwork

OBU .... On-Board Unit

RSU .... Road Side Units

TL .... Traffic Light

CC .... Control Center

JN .... Junction Name

VID .... Vehicle ID

RT .... Red Time

GT .... Green Time

YT .... Yellow Time

TON .... Total Number of Vehicles

DFC .... Driver Fatigue Counter

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Chapter 1

Introduction

Vehicular Ad-Hoc Network (VANET) is a form of ad hoc network that provides communication between vehicles (OBU-On Board Unit) and between infrastructure (RSU-Road Side Unit) and vehicles (OBU). Researchers have significantly contributed to achievements in VANET, and necessary solutions have been suggested. The Intelligent Transportation System (ITS) is an important application of VANET among other applications. In a VANET environment, these devices are enabled with On-Board Units (OBUs) or access points (APs) strategically located in fixed points along the road, they are referred to as Road Side Units (RSUs) [1]. High mobility of vehicles create major issues for traffic handling. Traffic management is an application of VANET. High dynamics of vehicles combined with usage of short range communications make the connectivity among the vehicles very unstable, so even the best effort service cannot be guaranteed. City traffic and Highway traffic is completely different. Highway traffic requires different set of policies for traffic handling. VANET can be used for safety applications as a primary goal; for driving support information services (information about parking places, points-of-interest, etc.) and, in some places, it can offer classic internet services including high quality media streaming and voice or video calling. Some of the VANET projects [2] are AKTIV (Traffic Management, Active Safety, Cooperative Cars using cellular nets), AIDE (Integration of driver assistant system and nomadic devices), COM2REACT (Road traffic control centre), COOPERS(Vehicle-to-infrastructure, traffic management), COMeSafety, CVIS, CyberCars-2, DAIDALOS-II, eImpact, FRAME (Framework for national European ITS architectures), GST, INTERSAFE-I (PReVENT), i-Way, MORYNE, NoWNetwork on Wheels, PReVENT (Reliable and secure communication for safety and infotainment), REPOSIT, SAFESPOT (Vehicle-to-vehicle communication, road safety, local dynamic map), SeVeCom, Watchover, WILLWARN (PReVENT)(Emergency warnings based on wireless communication) [1][2]. Figure 1 shows various applications of VANET.

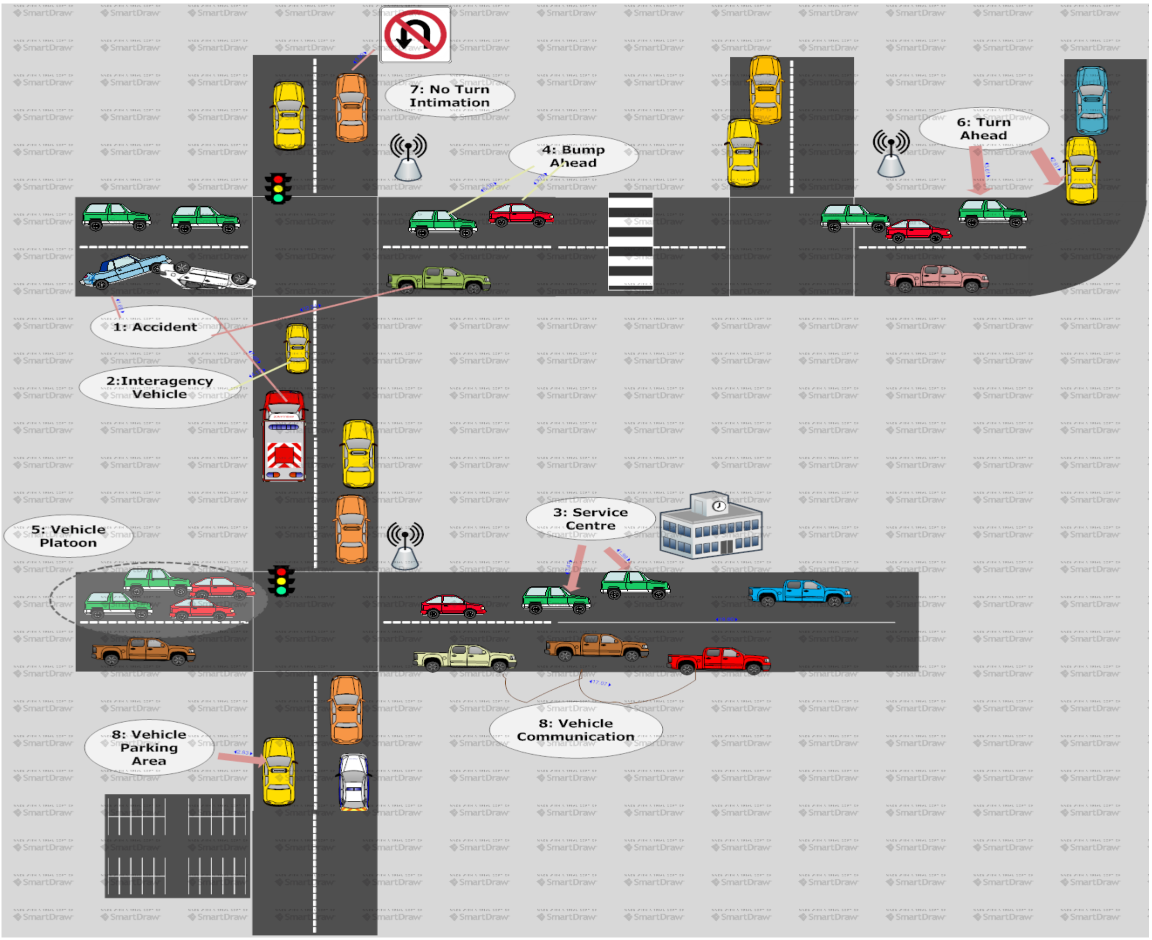

Figure 1.1: VANET

1.1 VANET Application Areas

Following are the different application areas where VANET can be used[1].

Active Safety

Active safety applications are geared primarily toward avoiding accidents and loss of life of the occupants of vehicles[4].

Public Service

VANET offers vehicles to send message to the workshop in case the vehicles face any problems.Also software of vehicles can be updated from car manufacturer server[4].

Improved driving

These applications are focused on improving traffic flow, thus reducing both congestion as well as accidents resulting from congestion, and reducing travel time[4].

Business/Entertainment

This class of applications may be motivated by the desire of passengers to communicate with either other vehicles or road-based destinations such as Internet hosts or the public service telephone network (PSTN)[4].

1.2 Characteristics of VANET

Sufficient energy and storage

A common characteristic of nodes in vehicular networks is that nodes have ample energy and computing power (including both storage and processing), since nodes are cars instead of small handheld devices. Higher computational Capabilities: Operating vehicles can afford significant computing, communication and sensing capabilities.

Predictable Mobility

Unlike general mobile ad hoc networks, where it is hard to predict the nodes mobility, vehicles can have very predictable movement that is (usually) limited to roadways.

Table I: Active Safety Applications

Situation/Purpose	**Application Examples**
A. Dangerous road features	1. Curve speed warning 2. Low bridge warning 3. Warning about violated traffic lights
B. Abnormal traffic and road conditions	1. Vehicle based road condition warning 2. Infrastucture based road conditions 3. Visibility enhancer 4. Work zone warning
C. Danger of collision	1. Blind spot warning 2. Lane change warning 3. Intersection collision warning 4. Forward/ Rear warning 5. Emergency Electronics brake lights 6. Rail collision warning 7. Warning about pedestrain crossing
D. Crash Imminent	1. Precrash sensing
E. Incident occurred	1. Post crash warning 2. Break down warning 3. SOS service

Table II: Public services

Situation/Purpose	**Application Examples**
A. Emergency response ‘	1. Approaching emergency vehicle warning 2. Emergency vehicle signal preemption 3. Emergency vehicle at scene warning
B. Support for authorities	1. Electronics licence plate 2. Electronic drivers license 3. Vehicle safety inspection 4. Stolen vehicles tracking

Table III: Improved Driving

Simulation/ Purpose	**Application Examples**
A. Enhanced Driving	1. Highway merge assistant 2. Left turn assist 3. Cooperative adaptive cruise control 4. Cooperative glare reduction 5. In-vehicle signal 6. Adaptive drive train management
B. Traffic Efficiently	1. Notification of crash or road surface conditions to a traffic operation center 2. Intelligent traffic flow control 3. Enhanced route guidance and navigation 4. Map download/update 5. Parking spot locator service

Table IV: Business/ Entertainment

Simulation/ Purpose	**Application Examples**
A. Vehicle Maintenance	1. Wireless diagnostic 2. Software update/flashing 3. Safety recall notice 4. Just-in-time repair notification
B. Mobile Services	1. Internet Service Provisioning 2. Instant Messaging 3. Pointof-interest notification
C. Enterprise solution	1. Fleet Management 2. Rental Car Processing 3. Area access control 4. Hazardous material cargo tracking
D. E-payment	1. Toll collection 2. Parking payment 3. Gas Payment

Roadway information is often available from positioning systems and map-based technologies such as GPS. Given the average speed, current speed, and road trajectory, the future position of a vehicle can be predicted[3][4].

Potentially Large Scale

Unlike most of the ad hoc networks studied in the literature that usually assume a limited area, VCNs can in principle extend over the entire road network and include many participants[3].

High Mobility

The environment in which vehicular networks operate is extremely dynamic, and includes extreme configurations: in highways, relative speed of up to 300 km/h may occur, while density of nodes may be 1-2 vehicles per kilometer in low busy roads[3].

Highly Dynamic Topology

Due to high speed of movement between vehicles, the topology of vehicular networks is always changing. For example, assume that the wireless transmission range of each vehicle is 250 m, so that there is a link between two cars if the distance between them is less than 250 m. In the worst case, if two cars with the speed of 60 mph (25 m/sec) are driving in opposite directions, the link will last only for at most 10 sec[3].

Various communications environments

Vehicular networks are usually operated in two typical communications environments. In highway traffic scenarios, the environment is relatively simple and straightforward (e.g., constrained one-dimensional movement); while in city conditions it becomes much more complex. The streets in a city are often separated by buildings, trees and other obstacles. Therefore, there isnt always a direct line of communications in the direction of intended data communication[3].

1.3 Challenges of VANET

1.3.1 Quality of Service

Applications envisioned for vehicular networks require fast association and low communication latency between communicating vehicles in order to guarantee: I) services reliability for safety-related applications while taking into consideration the time-sensitivity during messages transfer, and ii) the quality and continuity of service for passenger's oriented applications[4].

1.3.2 Market Introduction-penetration

Services and applications which are based on vehicle-to-vehicle communication and do not involve any infrastructure only provide value to the customer in case a sufficient penetration rate of equipped vehicles has been reached. For this reason, car manufacturers have to think about gradual market introduction strategies. Right from the start, car manufactures need to offer attractive infrastructure-based services (e.g. car-to-home data exchange, car-to-garage communications for remote diagnosis or Location Based Services) which provide clear customer benefit and motivate drivers to invest in additional wireless equipment for their vehicles. Eventually, after a longer period of time it is expected that this process will take up to 10 years high enough penetration rates can be reached to allow for purely ad-hoc vehicular communication services such as intersection collision warning, local danger warning, and the decentralized dissemination of real-time traffic flow information[4].

1.3.3 Security

Security is a crucial aspect in VANET in order to become a reliable and accepted system bringing safety on public roads. Vehicular communication and its services will only be a success and accepted by the customers if a high level of reliability and security can be provided. This includes authenticity, message integrity and source authentication, privacy, and robustness. the threat model considers four groups of attacks (attacks on car to infrastructure applications, on cars to home applications, on car to car traffic applications, and on car to routing protocols), and defines a set of guidelines which have been used for the proposal of a novel security framework[4].

Chapter 2

Literature Survey

Researchers are working on different approaches of Intelligent Traffic System. Focus is on Image Processing in VANET. Projects are in progress for improved safety in highways and comfort driving. Researchers have argued about optimization and feasibility of various approaches [7][8][9][10][17]. Image Processing approaches have some limitations in the heavy raining, foggy or sand storm weather and at very dark or unlined roads. If few parameters like drivers fatigue, dynamic nature of traffic, priority of vehicles etc. are ignored, VANET results may show remarkable performance improvement. In [17], researchers have tried to predict the traffic flow depending on time or Vehicle Queue Length only, that might help to solve the problem of traffic congestion and enhance the traffic flow. This scheme fails in some cases as they have missed other factors like congestion status in during previous traffic scheduling and congestion status of next traffic intersection. If these two criterions are considered, improvement in traffic flow is maintained. For VANETs, various criteria for traffic demand and variations and traffic control systems are to be considered.

2.1 Traffic demands and variations

Traffic demands can be distinguished into three categories: Short term, Medium term and Long Term. If traffic considered is for 15 minutes or 30 minutes, it is treated as short term traffic. Temporal shift or spatial shift for different conditions of weather, incidents and holidays may be considered as medium term traffic. Time span for traffic on daily basis and weekly basis for temporal conditions like constructions, and office hours are also considered as medium term traffic . Long span of time like annual and seasonal may be considered as long term traffic[6].

2.2 Different traffic control system

Different categories of Traffic Control Systems are as follows [10].

- Fixed time traffic control systems: Based on history and regular usage of road, fixed schedule can be allocated to traffic signal. Schedule is decided based on time of day or day of week from a set of pre-determined plans developed on the basis of historical traffic data.

- Responsive traffic control systems: Specific responsive system is design which monitor the traffic. Appropriate signal timing plans are implemented. Signal plans are prepared off-line in advance.

- Pattern matching traffic control systems:Specific pattern is prepared based on flow of traffic. Also Timing plans updated based on measured traffic flows and semi-automated optimization methods and then loaded into the system database.

- Adaptive traffic control system: In this system, traffic time is changing frequently. Based on different parameters, it changes frequently. It is on-line short term quick response without any kind of prediction. the comparision of basic control approaches is given into below table V.

Table I: Comparison of basic traffic control approaches

Traffic Control Strategy	**Advantages**	**Disadvantages**
Fixed Time Control	1.Cheapest to install and maintain 2.Can be implemented using non-centrally controlled 3.familiarity with setting for regular users	1.Requires large amount of data to be collected and maintained 2.Required operator reaction equipment to incidents 3.Disruption of plan changing
Pattern Matching and Pattern Matching with plan updating	1.Requires fewer detectors then adaptive control hence may be cheaper	1.Requires as much or more data to be collected as per fixed time systems. 2.Detectors failure possible.
Adaptive Control.	1.Less data needed to be collected in advance 2.Automatic reaction to incidents. 3.Monitor traffic conditions throughout network 4.trends in traffic are monitored and when detected , may used to update plans permanently.	1.Detector failure possible 2.most expensive to install and maintain. 3.Requires central control. 4.Maintainability critical

Table II: Comparison of adaptive traffic control approaches

Traffic Signal control System approach	**Mechanism**	**Advantages**	**Disadvantages**
Traffic green wave control algorithm (Offset algorithm).[1]	Establish cycle length and the offset between the phases of two adjacent intersections. Used Fuzzy logic simulator.	Fuzzy logic provides simplicity. introduction to new parameters like weather, vehicle type, minor events.	Not considered the parameter like driver fatigue , time of day.
Adaptive Traffic Lights Using Car-to-Car Communication using integrated simulation environment.[2]	Control delay and queue length are calculated at each ntersection .	Better than pre-timed algorithm and camera sensors system.	There is need of integrated simulation environment.
Online scheduling algorithm.	Apply platooning algorithm and job scheduling algorithm.	Better result compare to webster's method and vehical actuated traffic signal controller.	Not considered the parameter like low penetration rates, driver fatigue , time of day.
Dynamic Light Phase Plan Control (DT3P) Protocol.[5]	The protocol suggest to determine split time, cycle time, and the phase sequence according to real time collected data.	Better intersection performance has been detected compare to pre-timed and actuated traffic signal system.	Required more complex calculations at the intersection.
Clustering Algorithm[7]	This algorithm is combination of cluster and opportunistic dissemination technique to gather the required vehicles density information.	Holds good potential to improve traffic in urban areas.	Do Not considered the parameter like driver fatigue , time of day.

2.3 Adaptive traffic control system

In the Table-II compaision of vaious adaptive traffic control approaches is given. adaptive traffic control are dynamic controller which set signal according to the need of current situation.

2.4 Traffic Modeling

A simulation model as A computer program that uses mathematical models to conduct experiments with traffic events on a transportation facility or system over extended periods of time. Simulation models are designed to emulate the behavior of traffic in a transportation system over time and space to predict system performance. A simulation model studies a real-world system, taking into consideration the mathematical and logical concepts associated with the operation of the system, and emulates it with intricate computer software. Simulation model runs can be viewed as experiments performed in the laboratory rather than in the field. Simulation models are typically classified according to the level of detail at which they represent the traffic stream as follows.

Microsimulation Models Microsimulation is the dynamic and stochastic (random see note below) modeling of individual vehicle movements within a system of transportation facilities. Each vehicle is moved through the network of transportation facilities on a split second by split second basis according to the physical characteristics of the vehicle (length, maximum acceleration rate, etc.), the fundamental rules of motion (e.g. acceleration times time equals velocity, velocity times time equals distance) and rules of driver behavior (car following rules, lane changing rules, etc.)[19].

Microscopic Models Macroscopic models simulate traffic flow, taking into consideration cumulative traffic stream characteristics (speed, flow, and density) and their relationships to each other. The simulation in a macroscopic model takes place on a section-by-section basis rather than by tracking individual vehicles. Macroscopic models employ equations on the conservation of flow and on how traffic disturbances broadcast through the system like shockwaves. Macroscopic simulation models were originally developed to model traffic on distinct transportation sub networks, such as freeways, corridors (including freeways and parallel arterials), surface-street grid networks, and rural highways. They can be used to predict the spatial and sequential extent of congestion caused by traffic demand or incidents in a network; however, they cannot model the interactions of vehicles on alternative design configurations[19].

Mesoscopic Models Mesoscopic models combine the properties of both microscopic and macroscopic simulation models. Mesoscopic models are somewhat less consistent than microsimulation tools, but are superior to some other traffic analysis techniques. These models simulate individual vehicles, but describe their activities and interactions based on aggregate (macroscopic) relationships. They can simulate the routing of individual vehicles equipped with in-vehicle, real-time travel information systems. The travel times are determined from the simulated average speeds on the network links, which, in turn, are calculated from a speed-flow relationship. Typical applications of mesoscopic models are evaluations of traveler information systems[19].

2.5 Choice of Simulator

Several software tools were developed for VANET [15] . These tools can be classified into three categories:

Related to vehicle mobility issues: Mobility generators aim at generating traces files reflecting vehicles movements or mobility traces that are used as input for network generators. Their input parameter include vehicular speed, rates of arrival and departures; their output can be the mobility profiles and location for each vehicle in the simulation. In these tools, SUMO, MOVE, CityMob, and FreeSim are the most promising mobility simulators for VANET[17][18].

Related to network issues:There are network simulators for network related issues such as medium access control, signal propagation and strength. Examples are NS-2, NS-3, GloMoSim, Jist/SWANS.congestion on streets by using video or picture cameras. But this method is not always working as it would fail during the heavy raining, foggy or sand storm weather and at very dark or unlined roads.

Related to vehicle and network issues:VANET simulators or interlinking tools that provide both traffic flow and network simulation such as TraNS, NCTUns, iTetris and GrooveNet among others.

2.6 Mobility Generator Model : SUMO

Simulation of Urban MObility" (SUMO) is an open source, highly portable, microscopic road traffic simulation package designed to handle large road networks. It allows the user to build a customized road topology, in addition to the import of different readymade map formats of many cities and towns of the world. The development of SUMO started in the year 2000. The major reason for the development of an open source, microscopic road traffic simulation was to support the traffic research community with a tool with the ability to implement and evaluate own algorithms. The tool has no need for regarding all the needed things for obtaining a complete traffic simulation such as implementing and/or setting up methods for dealing with road networks, demand, and traffic controls.SUMO allows to generate a large number of different measures. All write the values they collect into specific files. Some of the available outputs (raw vehicle positions dump, trip information, vehicle routes information, and simulation state statistics) are triggered using command line options, the others have to be defined within "additional files". Figure 2.1 shows SUMO visualization[18].

SUMO, uses poison distribution to generate vehicles which are injected into the road network. XML scripts are written to generate nodes, links, routes and the network files among others, finally basing on the network file, a configuration file is generated for the simulation scenario.

A network (.net.xml file) holds the information about the structure of the map: nodes, edges, and connections between them. The network can be imported from popular digital maps such as OpenStreetMap and converted to a valid SUMO network by means of a series of scripts provided in the SUMO package. We have chosen OpenStreetMap (OSM) because it provides both, geographic data and traffic light information.

A journey is a vehicle movement from one location to another defined by: the starting edge (street), the destination edge, and the departure time. A route is an extended journey, meaning that, a route definition contains not only the first and the last edges, but also all the edges the vehicle will pass through. These routes are stored in a demand file (.rou.xml file) either through a route generator given by SUMO, existing routes imported from other software, or by hand. Additional files (.add.xml) can be added to SUMO information about the map or about the traffic lights. SUMO allows replacing and editing information on the cycles of traffic lights by manipulating a file with .add.xml extension. It is important to note that SUMO by default, provides the valid combination of states that the traffic light controller can go through inside the map specification file (.net.xml file), and an approximation of interval times for these states. This means that SUMO already incorporates a solver algorithm for the cycle program of traffic lights based on greedy and human knowledge. That solver will be called SCPG (SUMO Cycle Program Generator) in this project and it will be used in a comparison against our algorithm. The output of a SUMO simulation is registered in a journey information file (.tripinfo.xml) that contains information about each vehicles departure time, the time the vehicle waited to start at (offset), the time the vehicle arrived, the duration of its journey, and the number of steps in which the vehicle speed was below 0.1m/s (temporal stops in driving). This information is used to evaluate traffic lights cycle programs[18].

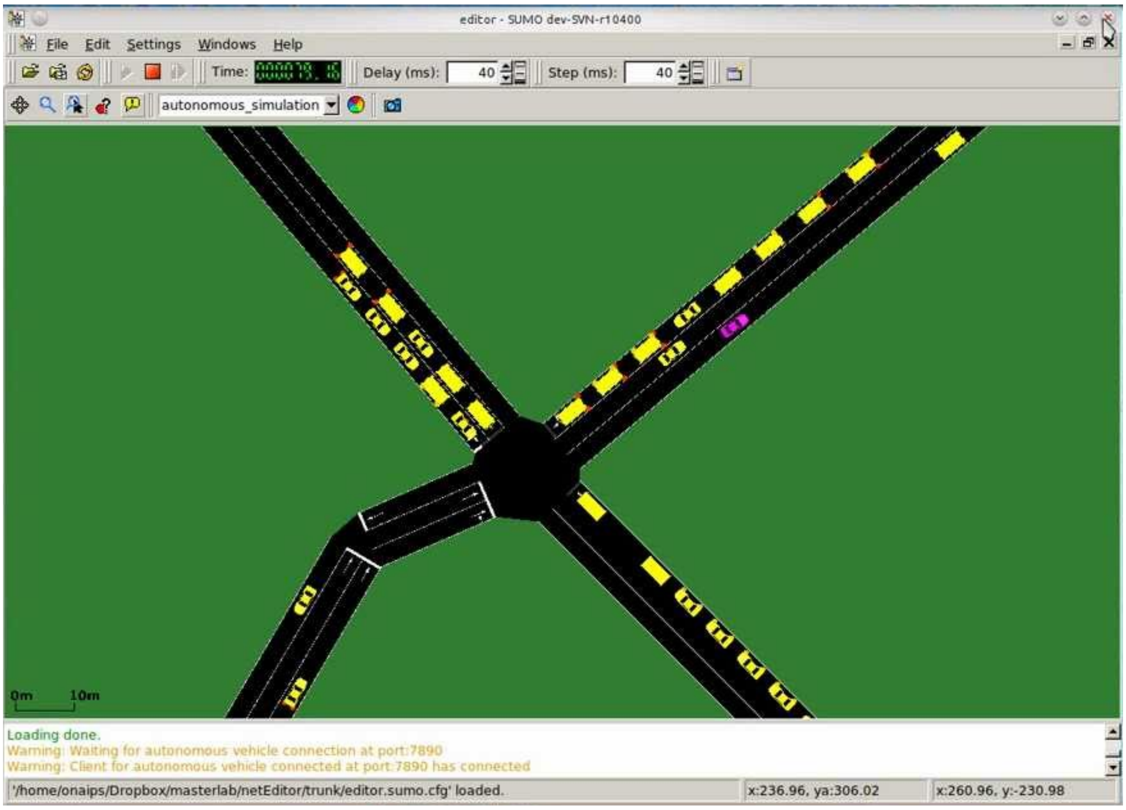

Figure 2.1: SUMO Mobility Generator GUI

2.6.1 Features

Includes all applications needed to prepare and perform a traffic simulation (network and routes import, DUA, simulation)

Simulation

1) Space-continuous and time-discrete vehicle movement
2) Different vehicle types
3) Multi-lane streets with lane changing
4) Different right-of-way rules, traffic lights
5) A fast openGL graphical user interface
6) Manages networks with several 10.000 edges (streets)
7) Fast execution speed (up to 100.000 vehicle updates/s on a 1GHz machine)

8) Network-wide, edge-based, vehicle-based, and detector-based outputs

8) Supports person-based inter-modal trips

Network Import

1) Imports VISUM, Vissim, Shapefiles, OSM, RoboCup, MATsim, OpenDRIVE, and XML-Descriptions

2) Missing values are determined via heuristics

Routing

1) Microscopic routes - each vehicle has an own one

2) Different Dynamic User Assignment algorithms

High portability

1) Only standard c++ and portable libraries are used

2) Packages for Windows main Linux distributions exist

High interoperability through usage of XML-data only

Open source (GPL)

2.7 Mobility Generator Model : MOVE

MObility model generator for Vehicular networks too shown in figure 2.2 is used to facilitate users to rapidly generate realistic mobility models for VANET simulations. MOVE is currently implemented in java and is built on top of an open source micro-traffic simulator SUMO. By providing a set of Graphical User Interfaces that automate the simulation script generation, MOVE allows the user to quickly generate realistic simulation scenarios without the hassle of writing simulation scripts as well as learning about the internal details of the simulator. The output of MOVE is a mobility trace file that contains information about realistic vehicle movements which can be immediately used by popular simulation tools such as ns-2[17].

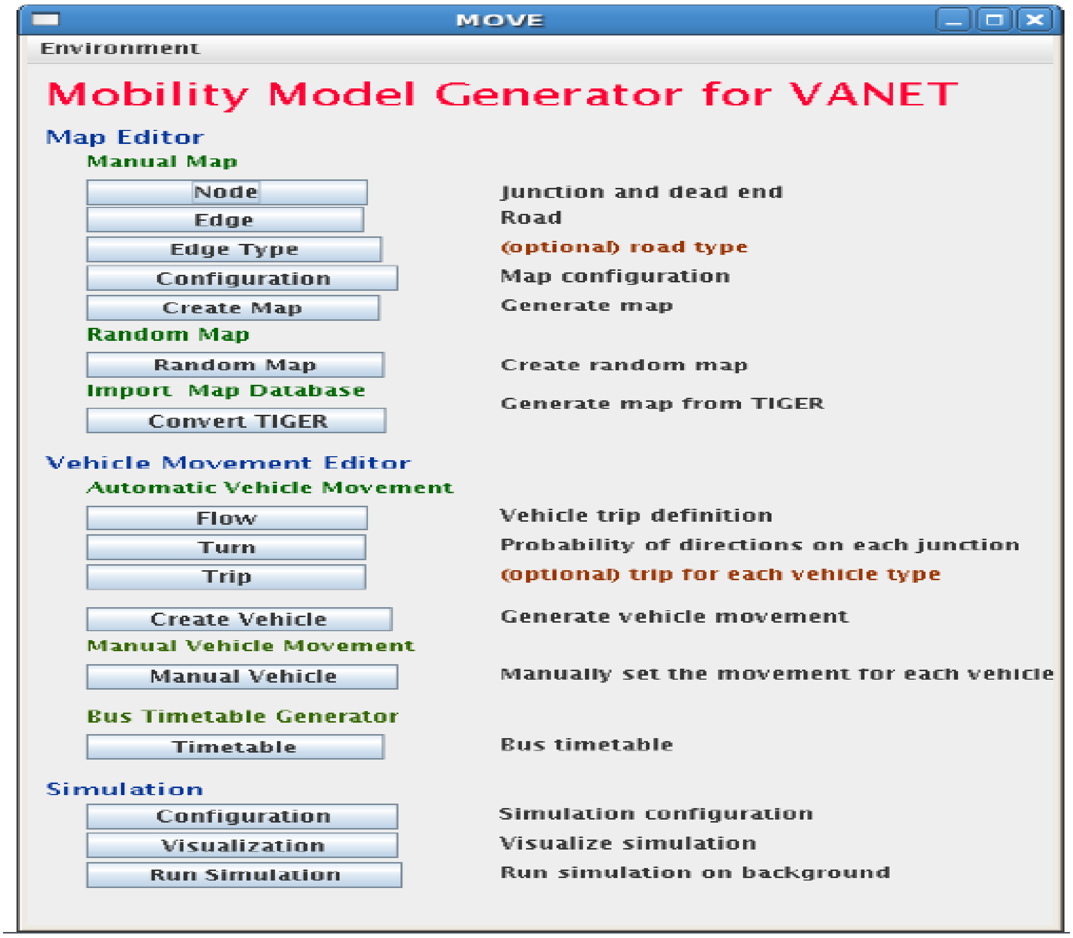

Figure 2.2: MOVE Mobility Generator GUI

2.8 Network Simulator: NS2.34

The Network Simulator (NS2.34) is a discrete event driven simulator developed at UC Berkeley. We are using Network Simulator NS2.34 for simulations of protocols. It provides substantial support for simulation of TCP, routing and multicast protocols over wired and wireless networks. Ns- 2 code is written either in C++ and OTCL and is kept in a separate file that is executed by OTCL interpreter, thus generating an output file for NAM (Network animator). It then plots the nodes in a position defined by the code script and exhibits the output of the nodes communicating with each other. It consists of two simulation tools. The network simulator (ns) contains

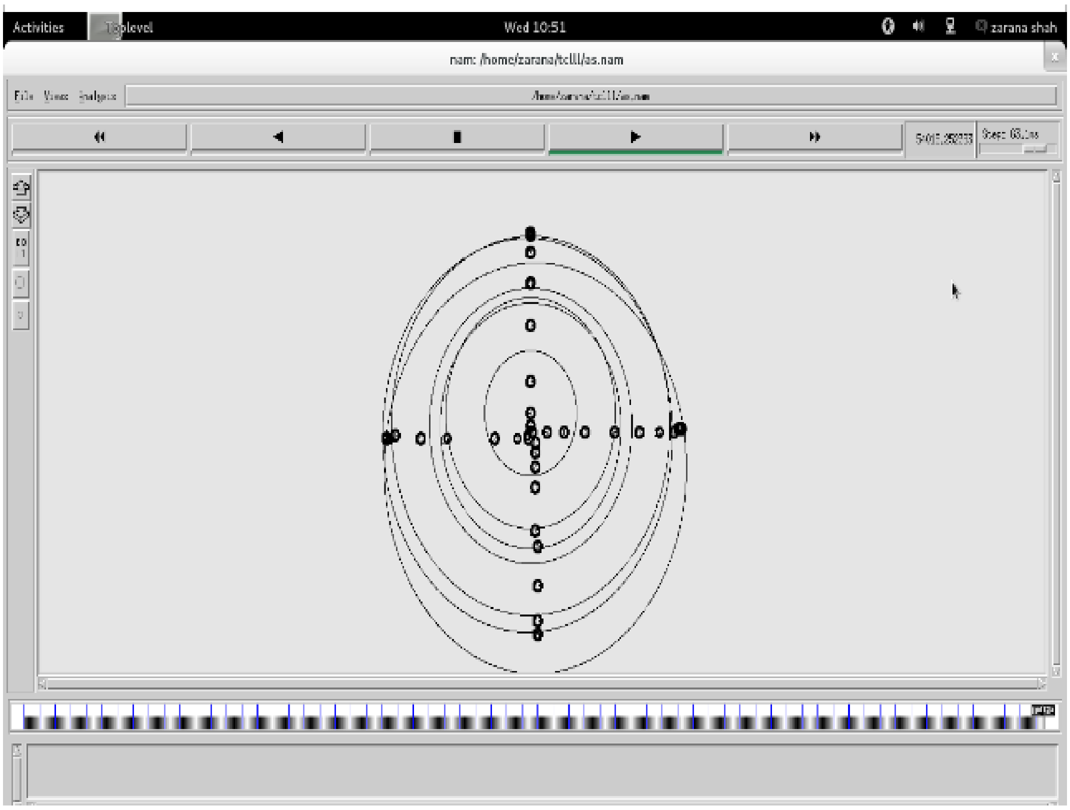

Figure 2.3: Scenario 1: Single Cross Road

all commonly used IP protocols. The network animator (NAM) is use to visualize the simulations[20].

Chapter 3

Proposed System Architecture

In vehicular ad hoc network, fixed cycle traffic lights decrease the throughput of traffic at intersections. It increases total average delay, as well as fuel consumption and air pollution.In proposed approach tried to reduce average number of halts for a vehicle and minimize total travel times in trips.

3.1 Proposed System

The main purpose of these techniques is to reduce the number of stops and minimize the travel times in trips.

In the approach group vehicles divided into equal size platoons , which can then be scheduled using scheduling algorithms to minimize the traveling time in trips.

The system has knowledge database for information infrastructure like road section length, lines number and speeding.

All vehicles are already equipped with Global Positioning System (GPS) unit that can provide location information with accuracy of few meters.

The required information level and data acquisition are provided by Vehicle-to-Vehicle and Vehicle-to-Infrastructure wireless communications.

Components of proposed model and their functions are briefly summarized in subsequent sections.

3.1.1 On-board Units (OBUs)

On-Board Units are responsible for car to car and car to infrastructure communications. An OBU is equipped with at least a single short range wireless communications network device. The network device is used to send, receive and forward data in ad hoc domain. The proposed model for the adaptive traffic light control system is shown in Figure

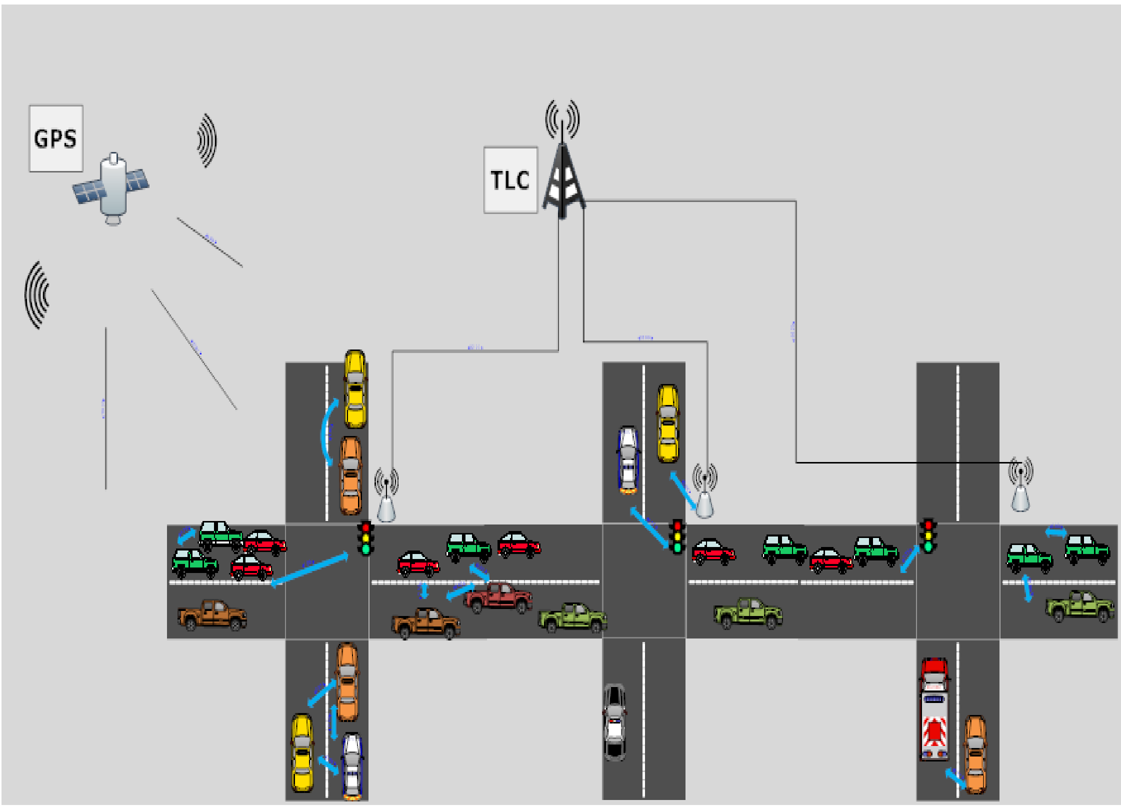

Figure 3.1: Traffic Signal Control System

3.1.2 Road-side Units (RSUs)

A Road-Side Unit is a physical device located at fixed positions along roads (and highways), or at dedicated locations (gas station, parking places, restaurants etc). An RSU is equipped with at least a network device for short range wireless communications radio technology. The main function of RSU are extending the communication range of an ad-hoc network, possibly running safety applications, possibly providing Internet connection to OBUs, possibly cooperating with other RSUs in forwarding or in distributing safety information etc.

3.1.3 Traffic Light (TL)

The Traffic Light has the function to adaptive and effective green time corresponding to each phase traffic light. We suppose that TL can wireless/wired communicate with OBUs, RSUs, and other adjacent TL, and takes into account the physical presence of vehicles, and queue length of vehicles for deciding signal timing. It also takes into account the predictive travel time and drivers behavior to calculate the order of the phases and the offset between traffic signals at adjacent intersections.

3.1.4 Control Center (CC)

Control Center serves as the point for the management of the transportation system. It integrates data from a variety of different sensor sources and provides a means for operators to manage traffic and inform the public from a centralized point. TCC directly communicates with RSUs and TLs, and examines data traffic information to identify potential traffic problems, and then develop scheduling strategies to reduce delay at traffic lights. The system is collecting data and predicting traffic on roadways throughout a large region. The Traffic Light uses information collected by OBUs and RSUs to automatically calculate the green time for each traffic light phases and the green wave offset for a wide range of cooperative intersections. In order to predict the green wave offset, we assume that the system monitors the action of the drivers, the position and the behavior of all other nearby vehicles. The effect of this approach is less stops on roadways resulting in increased traffic flow for equipped vehicles.

3.2 Challenges with the proposed approach

Define the different scheduling policy for traffic signal optimization.

Communication between V2V and V2I.

Mobility prediction of vehicle at different time and different situation.

3.3 Assumptions with the proposed approach

All vehicles are enabled with OBU (On board unit).

Traffic signal is available with each cross road.

All RSU are interconnected with each other.

Each Road consist of same number of lanes.

3.4 Constraints with the proposed approach

All vehicles may not follow suggested path.

Communication range of vehicles and infrastructures.

3.5 Flow chart

This flow chart indicates the signal state reception algorithm at the OBU. when vehicle OBU receive any broadcast packet at that time it will send unicast packet and check the signal phase and cycle duration from the broadcast packet.if grren on then continue its travelling and if red on then wait for green duration.

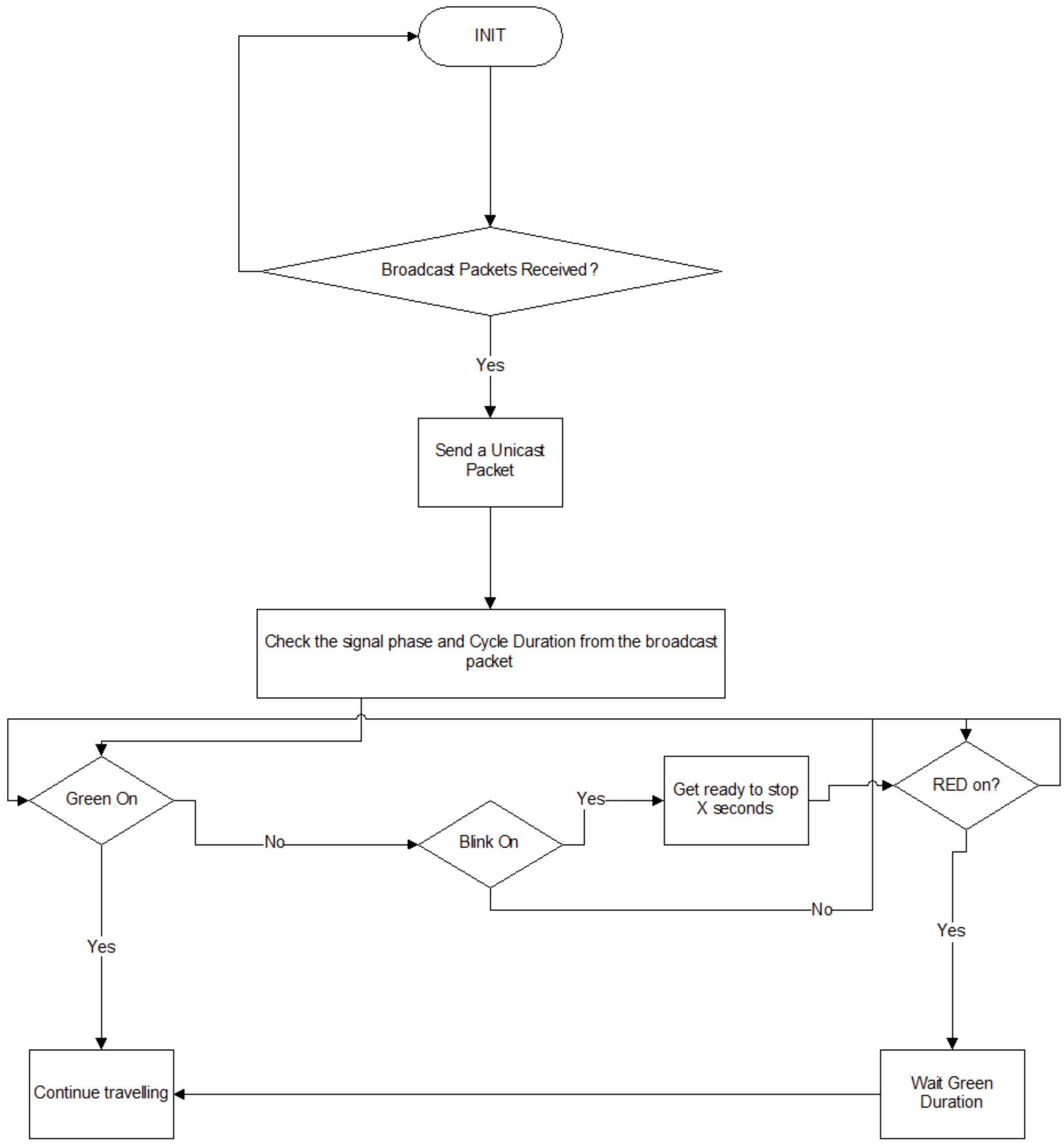

Figure 3.2: Flow chart of the signal state reception algorithm in the OBU

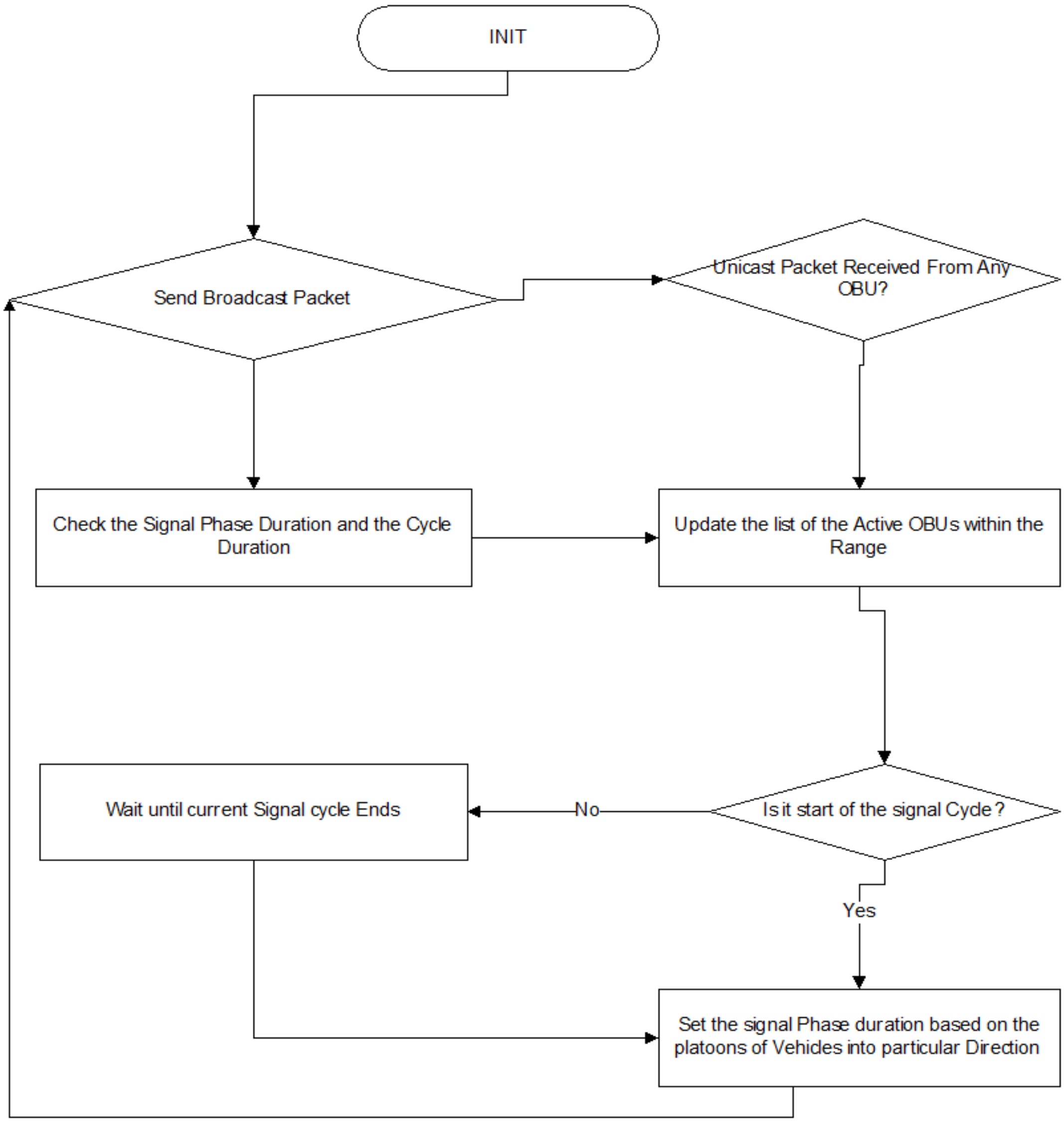

Figure 3.3: Flow chart of traffic signal broadcasting algorithm in the RSU

In this flow chart indicates traffic signal broadcasing algorithm in the RSU. RSU send broadcast packet to OBU in its range. then it will receive unicast packet from any OBU. RSU update the list of active OBU within the range. then RSU se the signal duratin based on the platoons of vehicles into particular direction.

Table I: Simulation Parameters

Parameters	**Specification**
Area	City Area
Traffic Light Support	Yes
Traffic Light Controller	Yes -Centralized
Type of Packet Send	UDP
Max. Speed of Vehicle	10/20/30 m/s
Safe Distance	Front and Rear -2 meter
Allow Overtaking	Yes
No. of LANE of Road	2
Width of LANE	6m
Priority Direction	North-South
Range of OBU and RSU	250 m

3.6 Simulation Parameters

Simulation Parameters are as given in Table I:

Chapter 4

Scheduling and Optimization Algorithms

4.1 Proposed Algorithms

4.1.1 Static Predefined Traffic light scheduling

In this traffic light scheduling all the junction traffic lights are enabled with predefined timings. This scheduling is similar to the existing pre timed scheduling.

Step 1: JN_i (i_{th} Node Junction) indicates intersection on the road and TL_i (i_{th} Traffic Light) indicates the selected traffic light of particular JN_i on the road;

Step 2: Traffic Light system started on Traffic signal. $\mathrm{TL}_i \leftarrow ON$;

Step 3: Assign Specific value to each Junction JN_i by calculating TL_i;

Step 4: Each side traffic will get time T$\leftarrow$ 150

For each TL_i set

Each Side have to wait for RT second and get Traffic will release for total time of GT+YT.

T$\leftarrow 150 Second$;

$P \leftarrow 30 Second$;

$RT \leftarrow 3 * T$;

$GT \leftarrow T - P$;

$YT \leftarrow P$;

Step 5: Exit;

4.1.2 Vehicle Based Actuated Traffic light Scheduling

In this traffic light scheduling if there are no vehicles at the intersection then the traffic light of that intersection will remain off for that particular time.

Step 1: JN_i (i_{th} Node Junction) indicates intersection on the road and TL_i (i_{th} Traffic Light) indicates the selected traffic light of particular JN_i on the road;

Step 2: Traffic Light system started on Traffic signal. $\mathrm{TL}_i \leftarrow ON$;

Step 3: For each JN_i set TL_i;

Step 4: If any vehicle enter into the coverage of particular TL_i, Vehicle will register its VID to TL_i .

$\mathrm{TL}_i \leftarrow VID$;

Step 5:IF$JN_i(\mathrm{TL}_i)$ = TRUE then

{

$\mathrm{TL}_i \leftarrow ON$;

$T \leftarrow 150 Second$;

$P \leftarrow 30 Second$;

$RT \leftarrow 3 * T$;

$GT \leftarrow T - P$;

$YT \leftarrow P$;

}

else

$\mathrm{TL}_i \leftarrow OFF$;

End if;

Step 6: *Exit*;

4.1.3 Shortest Platoons First Traffic light Scheduling

In this traffic light scheduling all the vehicle communicate with roadside infrastructure and each roadside infrastructure are connected with control centre. Then CC will schedule traffic lights as per size of platoons.

Step 1: JN_i (i_{th} Node Junction) indicates intersection on the road and TL_i (i_{th} Traffic Light) indicates the selected traffic light of particular JN_i on the road;

Step 2: *Every* Road junction connected with RIU(Roadside Infrastructure Unit) and Each RIU are connected with CC(Control Centre).

Step 3: $TrafficLightsystemstartedonTrafficsignal.$ $TL_i \leftarrow ON$;

Step 4: For each JN_i set TL_i;

Step 5: *Each* vehicle when enter into the coverage of particular RIU_i. vehicle will register its Vehicle ID(VID) and Vehicle Current Location (VLOC) to RIU_i.

$RIU_i \leftarrow VID, VLOC$

Step 6:RIU will collect all the data and make the platoons of vehicles using $VLOC_i$ of vehicles and send it to the CC.

CC $\leftarrow RIU$;

Step 7:CC will schedule eachTL_i as shortest platoons first and according to the size of platoon it will set theTL_i at each JN_i;

$TL_i \leftarrow Scheduled\_DataCC$

Step 8: If two platoons having same size then FCFS (First come first serve);

Step 9: IF JN_i(RIU) $\leftarrow TRUEthen$

{

$TL_i \leftarrow ON$;

$GT \leftarrow (F * N) seconds$;

$YT \leftarrow (F/4) seconds$;

$RT \leftarrow (F * TON) seconds$;

}

Else

$\mathrm{TL}_i \leftarrow OFF$;

End If;

Step 10: *Exit.*

NOTE: Where F indicates minimum average time required for one vehicle to cross the intersection.

NOTE:N indicates number of vehicles into particular platoon at TL_i of intersection JN_i.

NOTE: TON indicates the total number of vehicles at intersection JN_i at time T.

4.1.4 Multiple Queue Traffic light Scheduling

In this traffic light scheduling all the vehicle communicate with roadside infrastructure and each roadside infrastructure are connected with control centre. The control centre will use multiple queue like lower level, medium level and higher level queue. In this emergency vehicles are always get higher priority compare to other vehicles.

Step 1: JN_i (i_{th} Node Junction) indicates intersection on the road and TL_i (i_{th} Traffic Light) indicates the selected traffic light of particular JN_i on the road;

Step 2: *Every*Road junction connected with RIU(Roadside Infrastructure Unit) and Each RIU are connected with CC(Control Centre).

Step 3: $TrafficLightsystemstartedonTrafficsignal.\mathrm{TL}_i \leftarrow ON$;

Step 4: For each JN_i set TL_i;

Step 5: *Each* vehicle when enter into the coverage of particular RIU_i. vehicle will register its Vehicle ID(VID) and Vehicle Current Location (VLOC) to RIU_i.

$RIU_i \leftarrow VID, VLOC$

Step 6:RIU will collect all the data and make the platoons of vehicles using $VLOC_i$ of vehicles and send it to the CC.

$\mathrm{CC} \leftarrow RIU$;

Step 7:CC will schedule eachTL_i;

Step 8: If vehicles data received at RIU_i of Particular JN_i then

{

TL_i = ON;

Else

TL_i = Off;

}

End if;

Step 9: Initially CC will keep all the traffic lanes into lowest level queue;

Step 10: CC will do the scheduling based on N_{Veh} which indicated no. of vehicle and X_i indicated minimum threshold value for ith LAN.

If N_{Veh} >X_i Then

{The lane is shifted to NEXT higher level queue;}

End if:

If N_{Veh} <= X_i Then

{The lane remains into the lowest level queue;}

End if:

If $Veh_{Emergency}$=TRUE then

{The lane is shifted to the highest level queue;}

End if:

Step 11: CC will checks If multiple lanes into highest level then they served according to the FCFS.

Step 12: CC will serve queue according to their level and on each level the lanes are served as per RR scheduling.

Step 13:

IF TL$_i$ = ON ; then

{

GT $\leftarrow (F * N)seconds$;

$YT \leftarrow (F/4)seconds$;

$RT \leftarrow (F * TON)seconds$;

}

End If;

Where F indicates minimum average time required for one vehicle to cross the intersection. N indicates number of vehicles into particular platoon at TL_i of intersection JN_i. TON indicates the total number of vehicles at intersection JN_i at time T.

Step 14: *Exit.*

4.1.5 Multiple Queue Traffic light Scheduling with Factor D

This scheduling scheme is similar to the above. But this would be of significant to the drivers benefit because in this driver fatigue is considered as factor D.

Step 1: JN_i (i_{th} Node Junction) indicates intersection on the road and TL_i (i_{th} Traffic Light) indicates the selected traffic light of particular JN_i on the road;

Step 2: *Every* Road junction connected with RIU(Roadside Infrastructure Unit) and Each RIU are connected with CC(Control Centre).

Step 3: $DFCindicatesDriverFatigueCounter$;

Step 4:A vehicle when starts its travelling at that time DFC will be initialized by 0.

Step 5: $TrafficLightsystemstartedon$ Traffic signal.$TL_i \leftarrow ON$;

Step 6: For each JN_i set TL_i;

Step 7: *Each* vehicle when enter into the coverage of particular RIU_i. vehicle will register its Vehicle ID(VID), Vehicle Current Location (VLOC) and DFC to RIU_i.

$RIU_i \leftarrow VID, VLOC, DFC$

Step 8:RIU will collect all the data and make the platoons of vehicles using $VLOC_i$ of vehicles and send it to the CC.

CC $\leftarrow RIU$;

Step 9: CC will schedule eachTL_i;

Step 10: If vehicles data received at RIU_i of Particular JN_i then

{

TL_i = ON;

Else

TL_i = Off;

}

End if;

Step 11: Initially CC will keep all the traffic lanes into lowest level queue;

Step 12: CC will do the scheduling based on N_{Veh} which indicated no. of vehicle, X_i indicated minimum threshold value for ith LAN and $Y_i indicates threshold value for Driver Fatigue$

If $N_{Veh} > X_i$ Then

{The lane is shifted to NEXT higher level queue;}

End if:

If $N_{Veh} <= X_i$ Then

{The lane remains into the lowest level queue;}

End if:

If $Veh_{Emergency}$=TRUE then

{The lane is shifted to the highest level queue;}

End if:

IF TH_{dfc} ¿Y_i then

{ The lane is shifted to NEXT higher level queue;} End If; **Step 13:** CC will checks If multiple lanes into highest level then they served according to the FCFS.

Step 14: CC will serve queue according to their level and on each level the lanes are served as per RR scheduling.

Step 15:

IF TL_i = ON ; then

{

GT $\leftarrow (F * N) seconds$;

$YT \leftarrow (F/4) seconds$;

$RT \leftarrow (F * TON) seconds$;

}

End If;

Where F indicates minimum average time required for one vehicle to cross the intersection. N indicates number of vehicles into particular platoon at TL_i of intersection JN_i. TON indicates the total number of vehicles at intersection JN_i at time T.

Step 16: If vehicle get RT at Particular JNi then { DFC $\leftarrow DFC + 1; Endif;$ }

Step 17: Exit

4.2 Analysis of proposed approaches

In Static Predefined Traffic light scheduling approach used pre-stored signal timing plans calculated off-line, based on historical traffic data,in the same way as the existing control strategies. The selected timing plan are static. In Vehicle based actuated traffic light Scheduling uses both vehicle information and a set of control parameters to operate the intersection in a more efficient way. With the use of actuated traffic light Scheduling, intersection approaches are allocated green times based on their current demand. If there is no demand at intersection , then the traffic signal will be off. In Shortest Platoons First Traffic light Scheduling uses both Roadside infrastructure information and a set of control parameters to operate the intersection in a more efficient way. With the use of actuated traffic light Scheduling, intersection approaches are allocated green times based on their current demand. If there is no demand at intersection , then the traffic signal will be off. In this method the control centre collect all the data from platoons of vehicles. Multiple Queue based Traffic light Scheduling would be of significant benefit because of its ability to reduce delay times, travel times, number of stops, and vehicular emissions in response to the change in traffic patterns. The objective of this research is to develop an integrated adaptive algorithm that can be readily added to actuated traffic light Scheduling. This would provide a cost effective procedure to improve the performance of current traffic control systems without adding major cost to the system. This Multiple Queue based Traffic light scheduling with Factor D approach consists of all the characteristics of Multiple Queue based Traffic light Scheduling and it would be of significant to the drivers

Table I: Algorithm Comparasion

Algorithm	**A**	**B**	**C**	**D**	**E**
Nature	Static	Dynamic	Dynamic	Dynamic	Dynamic
Scheduling Dependency	Predefined Traffic	Depends on Vehicle	Depends on platoons of Vehicle	Depends of type of queue in which vehicle lane resides	Depends of type of queue vehicle lane resides and Driver Fatigue
Complexity	Low	Low	Medium	High	High
Suitable Traffic for	Low	Medium	Medium	Heavy, Medium	Heavy, Medium
Processing at CC Side	NA	NA	Medium	High	High
Unnecessary Delay	High	High	Medium	Minimum	Minimum

benefit because in this driver fatigue will be also considered as factor D. Comparison of Proposed approach with respect to various parameters are as below.

4.3 Results and Discussion

4.3.1 Simulator

Various Simulators are available in the market. We categories them into main three category: Mobility Generator Simulator, Network Simulator and VANET simulator which is a combination of mobility and network simulator.
By comparing them we found suitable simulators are SUMO(Simulation of Urban MObility) as a Mobility generator and NS2.34 with 802.11P support selected as a network simulator. We also use MOVE for user friendliness.

4.3.2 Simulation Setup and Scenarios

Here we analyze the different approaches in three different scenarios. Scenario-1 is for Single cross road, scenario-2 is for multiple cross road with T section and scenario-3 is for city.

Step 1: Manually create your own map nodes (hello.nod.xml)

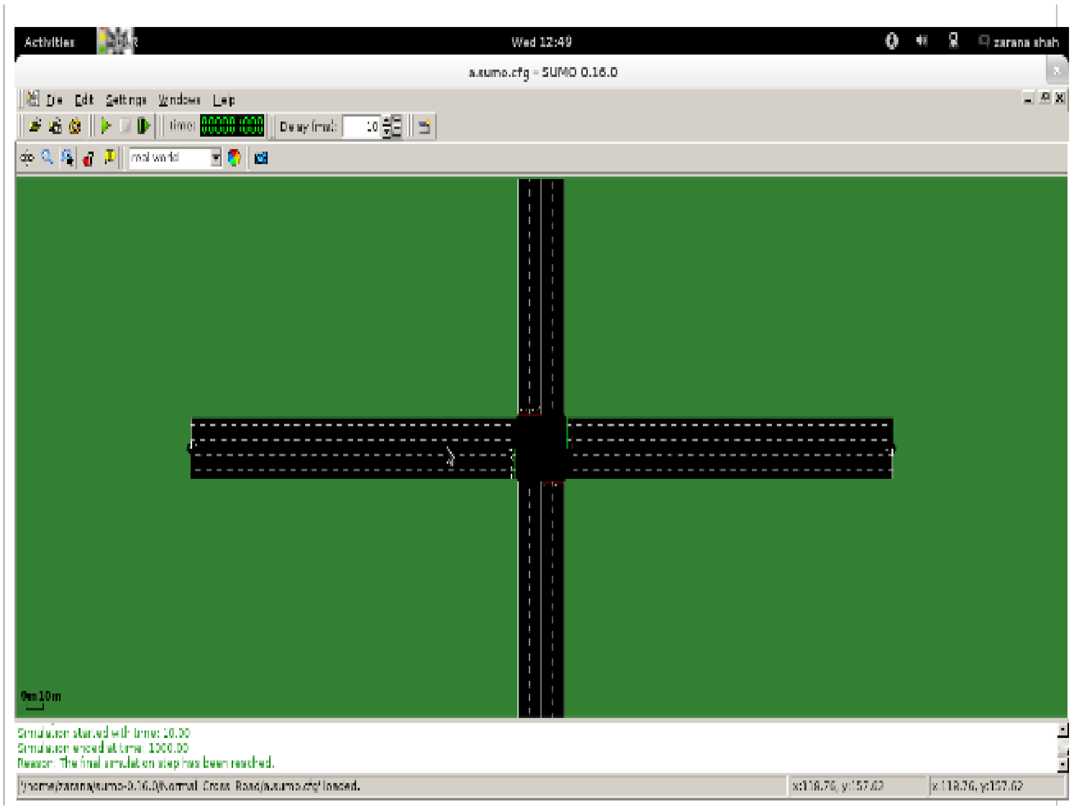

Figure 4.1: Scenario 1: Single Cross Road

Step 2: Manually create your own map edge (hello.edg.xml)

Step 3: Create map configuration file (hello.netc.cfg).

Step 4: Create Route configuration file(hello.rou.xml)

Step 5: Generate the Map file (hello.net.xml) using netconvert command. **Step 6:** Implemented different approaches logic into trafficlights of .net xml using Traci interface and .py script

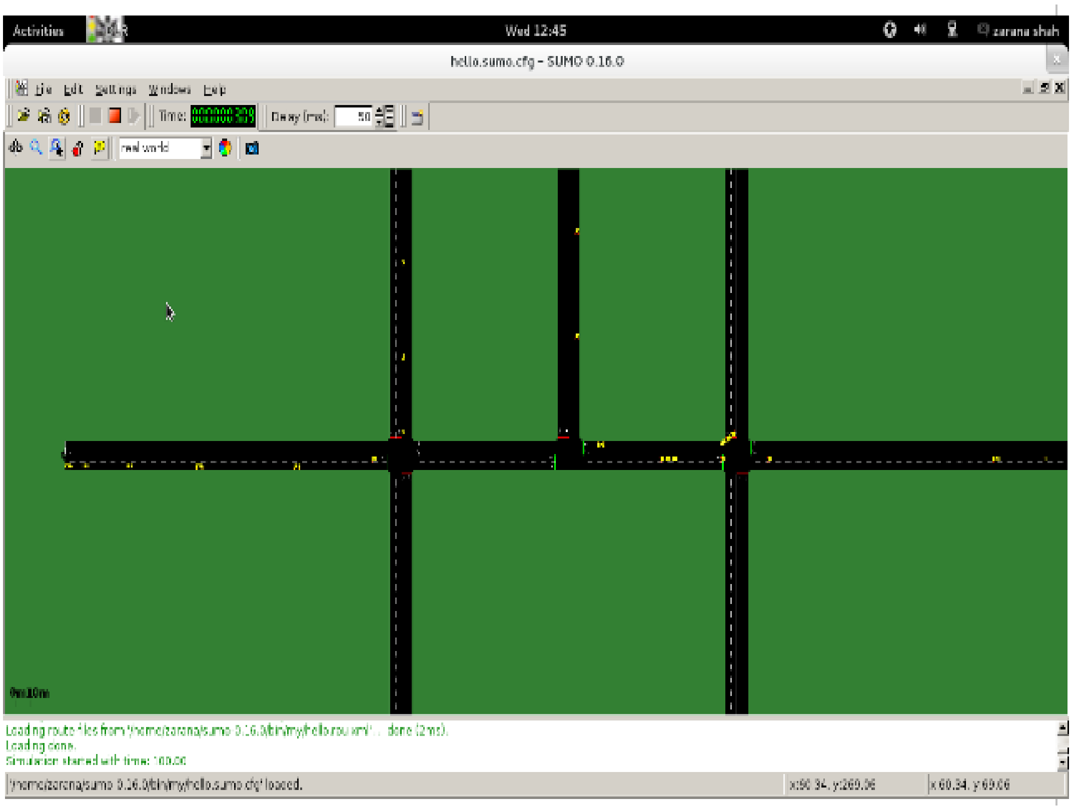

Figure 4.2: Scenario 2: Multiple Cross Roads with T Section

Step 7: Simulation setup (hello.sumo.tr and hello.sumo.cfg)

Step 8: Visualize Simulation

Step 9: Generating Trace files using traceExporter utility.

Step 10: Simulated different Approaches

Step 11: From the Mobility module of MOVE generate trace file(*.tr) and Traffic module of MOVE generate (*.tcl)

Step 12: Done the integration of NS2.34 with IEEE 802.11P

Step 13: Run the generated tcl in NS2.34.

Step 14: Run the generated .nam in NS2.34

Step 15: Do the analysis of result for the proposed different approach by using different awk scripts.

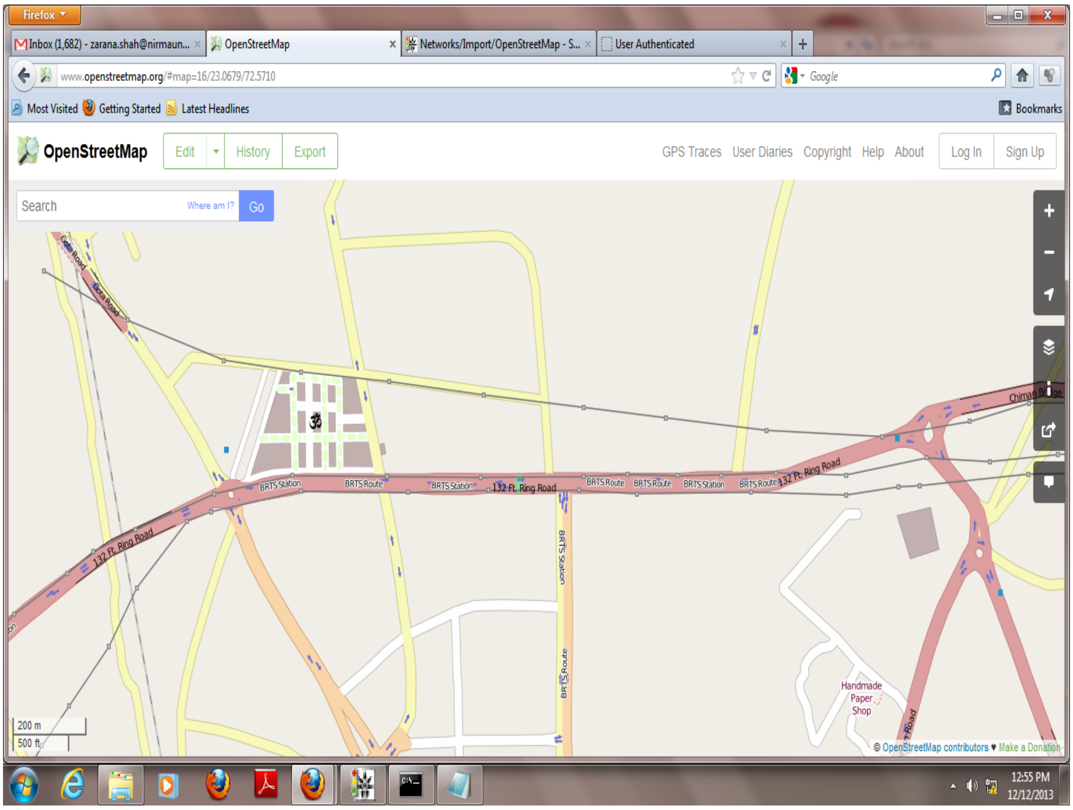

Figure 4.3: Open Street Map City Scenario

4.4 Results

Here we analyze total five different approaches in all three scenarios like Static approach; Vehicle actuated approach, Shortest Path First approach, Multiple Queue approach, Multiple Queue with driver fatigue. In analysis we had taken five results for each approach and for each scenario. In table-I we represented average value of five different result.

Figure 4.5 shows the comparison between all the approaches for single cross road for average time of five cases. Fig.4.6 shows the comparison between all the approaches for Multiple cross road for average time of five cases and Fig.4.7 shows the comparison between all the approaches for city road for average time of five cases
In this compared total time delay with static approach and based on that for each

Table II: Result

	Low Traffic	**Medium Traffic**	**Heavy Traffic**
Scenario 1			
Static	60.41	110.4	225.56
Vehicle Actuated	55.44	106.62	223.47
Shortest Platoon First	51.38	102.57	220.32
Multiple Queue	46.7	99.4	217.4
Multiple Queue with Driver Fatigue	42.75	97.11	214.12
Scenario 2			
Static	131.07	250.5	510.38
Vehicle Actuated	125.5	244.35	501.52
Shortest Platoon First	114.84	239.93	497.49
Multiple Queue	109.4	236.4	493.55
Multiple Queue with Driver Fatigue	106.03	234.61	491.15
Scenario 3			
Static	524.44	995.41	1980.53
Vehicle Actuated	510.01	991.05	1976.43
Shortest Platoon First	503.58	985.58	1970.72
Multiple Queue	499.8	981.34	1966.55
Multiple Queue with Driver Fatigue	494.65	977.8	1960.28

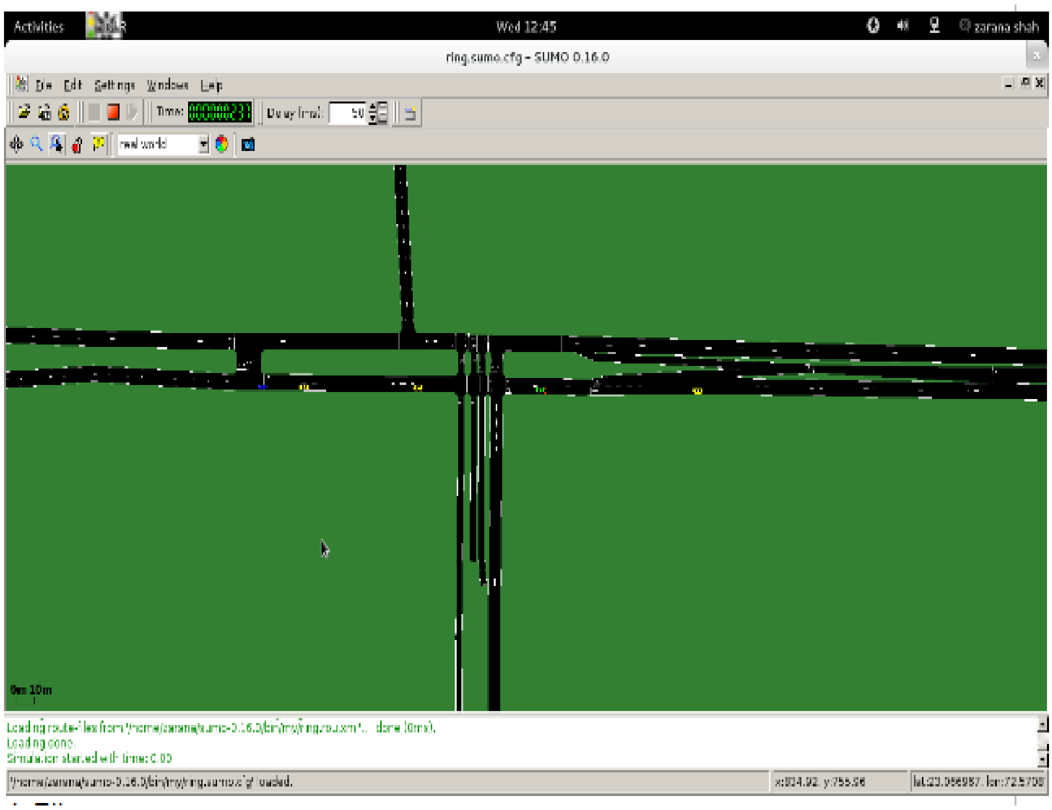

Figure 4.4: Scenario 3: City Scenario

scenario we get different benefits as shown in figure 4.8, figure 4.9 and fig. 4.10 As a conclusion each approach is more effective for lower traffic. Total benefit gain through system is more for less traffic. Benefit is inversely proposal to number of vehicle. When traffic increases, the benefit decreases compared to less traffic.

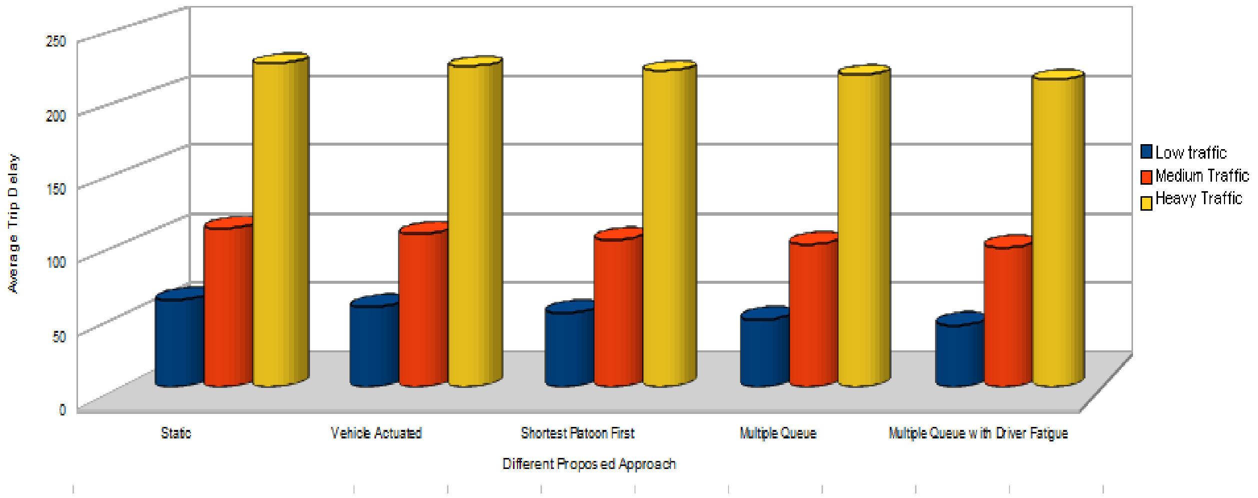

Figure 4.5: Scenario 1: Single Cross Roads

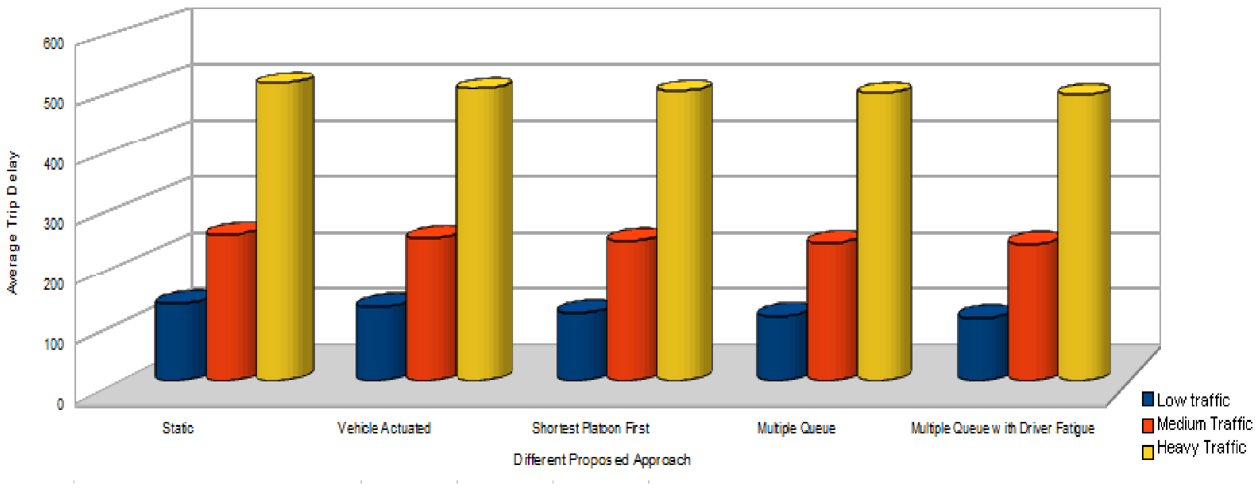

Figure 4.6: Scenario 2: Multiple Cross Roads with T-section

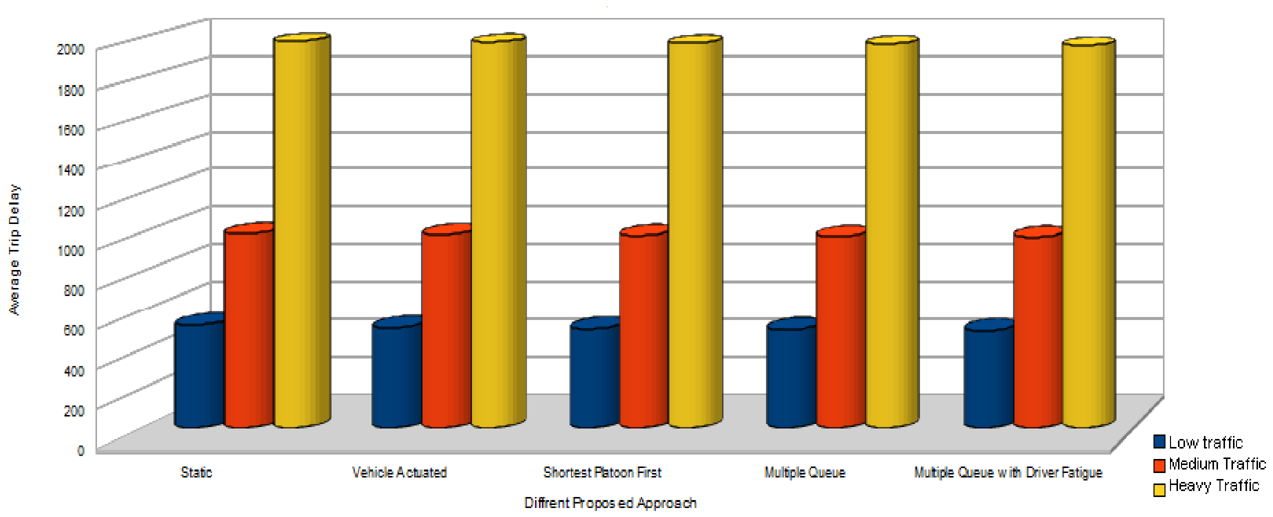

Figure 4.7: Scenario 3: City Scenario

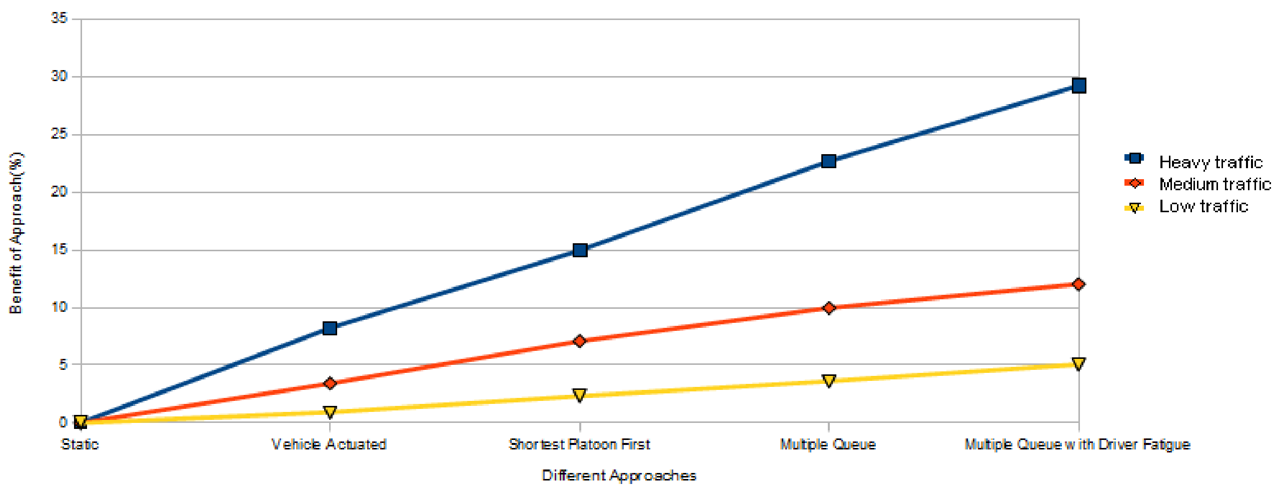

Figure 4.8: Scenario 1: Single Cross Roads

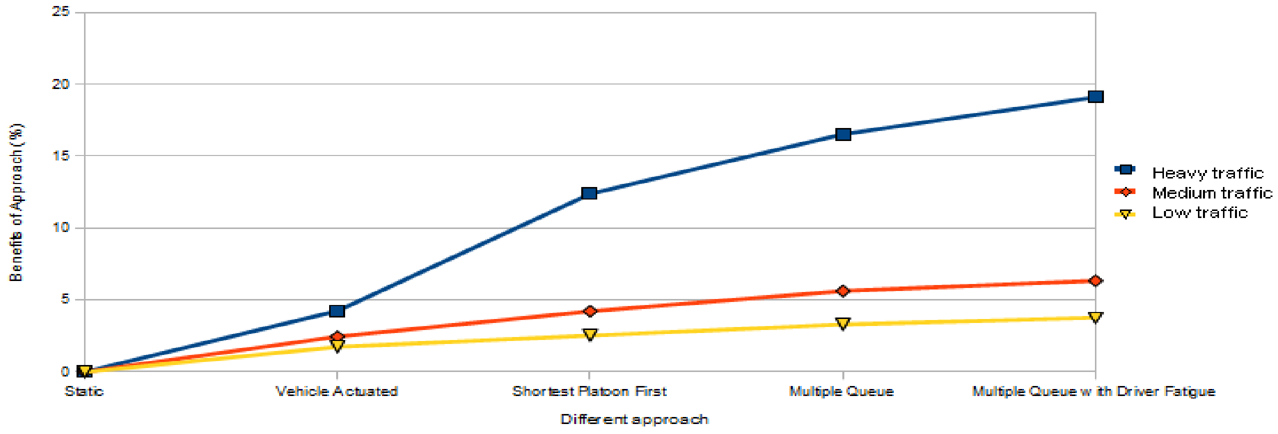

Figure 4.9: Scenario 2: Multiple Cross Roads with T-section

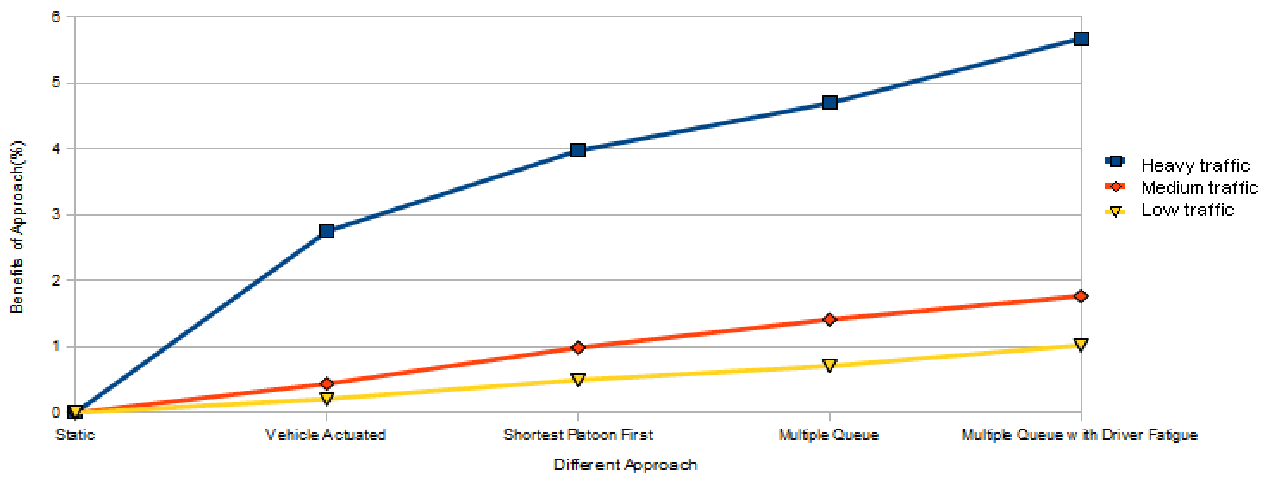

Figure 4.10: Scenario 3: City Scenario

Chapter 5

Conclusions

In this paper, different Traffic control systems are covered and their applications related to traffic optimization are discussed. Different approaches are proposed, for static predefined traffic light scheduling, Vehicle Based Actuated Traffic light Scheduling, Shortest Platoons First Traffic light Scheduling, Multiple Queue based Traffic light Scheduling and Multiple Queue based Traffic light Scheduling with Driver fatigue factor. In future, the same will be implemented in realistic scenario for Ahmedabad City junctions and the implementation results will be analysed. SUMO and NS2 will be used for implementing the same and comparison based on their performance and scheduling optimization will be demonstrated.

As shown in result, in different approaches trip delay decreasing and benefits through the approach is increasing as shown in figure 4.5,figure.4.6 and figure 4.7.As shown in figure 4.8 ,figure 4.9 and figure 4.10,conclude that Vehicle Actuate approach is better than static and Shortest Platoons First is better than Vehicle Actuated. Same way as shown in figure 4.8 ,figure 4.9 and figure 4.10, conclude that Multiple Queue is giving better result then shortest Platoons First.Finally conclude that Multiple Queue With driver Fatique is giving best results among all.

Chapter 6

Future Work

In this thesis work we considered all the same vehicles in simulations and assumed that all the vehicles are VANET facilitated. Here considered lane-based traffic for vehicle mobility. In future plan to analyze our approach for various vehicles and lane-less traffic movement which is more reasonable for representing traffic in rising countries. We will work on more optimized scheduling. it will also be incorporated in the proposed approach.

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