Adaptive Traffic Light Algorithm for Optimization of Multiple Intersections

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Adaptive Traffic Light Algorithm for Optimization of Multiple Intersections

Major Project

Submitted in partial fulfillment of the requirements

for the degree of

Master of Technology in Computer Science and Engineering

Submitted By

Shailendrasinh Chauhan

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Guided By

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AHMEDABAD-382481

May 2015

Certificate

This is to certify that the major project entitled **"Adaptive Traffic Light Algorithm for Optimization of Multiple Intersections"** submitted by **Shailendrasinh Chauhan (Roll No: 13MCEN02)**, towards the partial fulfillment of the requirements for the award of degree of Master of Technology in Computer Science and Engineering(Networking Technologies), Institute of Technology of Nirma University, Ahmedabad, is the record of work carried out by him 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 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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Statement of Originality

I, **Shailendrasinh Chauhan**, Roll. No. **13MCEN02**, give undertaking that the Major Project entitled "**Adaptive Traffic Light Algorithm for Optimization of Multiple Intersections**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Computer Science & Engineering (Networking Technologies)** of Institute of Technology, Nirma University, Ahmedabad, contains no material that has been awarded for any degree or diploma in any university or school in any territory to the best of my knowledge. It is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. It contains no material that is previously published or written, except where reference 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.

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Abstract

In road transportation, various strategies can be applied to traffic controller. All traffic light signals can be managed in two different ways. First is at static traffic control and another one is at adaptive or dynamic traffic light control. In this report, the analysis of various methods is described which is used for traffic light signal control to make traffic signal adaptive in nature using ITS (Intelligent Transportation System). To overcome drawback of existing static traffic light control system we have proposed an algorithm which increases the flow of multiple traffic light junctions compared to the flow which we get in static traffic light junctions. Proposed algorithm is increases utilization of each intersection and decreases trip time for every vehicles as well as global road network such as grid road network by making all traffic light control(TLC) adaptive using traffic flow information, speed information and occupancy at every road connected to respective traffic light junctions. Proposed also maintains schedule global road network. It also takes care about priorities given to roads based on their mean speed. Proposed algorithm is implemented and analyzed using suitable simulator SUMO(Simulation of Urban Mobility) and Python scripts.

Abbreviations

ITS	Intelligent transportation System.
TLC	Traffic Light Control.
SUMO	Simulation for Urban MObility.
WSN	Wireless Sensor Network.
VANET	Vehicular Ad-hoc Network.
TraCI	Traffic Control Interface.

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Chapter 1

Introduction

Intelligent transportation system (ITS) is traffic management system that manages various traffics including road traffic for optimizing the speed of the traffic flow, improving traffic safety, minimizing average waiting time for vehicles and minimizing the energy consumption of vehicles running on the roads [1].
Traffic light control (TLC) is one of the main branch of ITS. Existing traffic light control systems use following strategies:

- fixed-time
- actuated
- adaptive (dynamic)

All strategies are having same purpose, to maximize safety, speed and energy efficiency or minimize waiting time, number of vehicle stops. It is difficult in a dynamical traffic systems in which each traffic light controller must consider so many parameters. Parameters varies as pr necessity. Those parameters can be number of roads connected to junction, number of lanes in road, traffic density, time of day, pedestrian traffic and effects on other roads [1].
Various artificial intelligence concepts can also be used for adaptive light signal control, such as Neural Network, Genetic Algorithm,Game theory, Q-Learning, Fuzzy Logic Control and so on. ITS can also be managed using Vehicular Ad-hoc Network (VANET), vehicle-to-vehicle communication, sensor networks etc. Road traffic network can also be considered as network having distributed servers which are connected by one or more network connection which is similar to Queueing Model. By considering queueing model,

all TLCs at different intersections can be considered as servers and vehicles can be considered as processes waiting to be served by the servers.

There are so many solutions proposed and existing to solve traffic jam issues. Most of the solutions use intrusive sensors like loop detectors, micro-loop probes, pneumatic road tubes etc. However these technique disrupt traffic during implementation, road repair which is more costly and needs more maintenance. Other technologies which use sensors like video, radar and ultrasonic is more costlier and depend on environmental condition[2]. Technologies like Wireless Sensor Networks (WSN) and VANET (Vehicular Ad-hoc Network) is much better during consideration of cost and scalability.

Traffic congestion is also one of the major issue in large cities. Major reason for congestion is improper synchronization or control of traffic lights according to traffic conditions at particular junction. Vehicular traffic congestion is also a hot research area as it effects economy and social growth of countries[3]. We can reduce traffic congestion using ITS techniques[4].

Main aim of adaptive traffic control is to reduce congestion compared to fixed static traffic signal control. Adaptive traffic controller collects information of traffic scenario and takes decision accordingly for cycle time like green state duration, yellow state duration and red state duration of junction [5]. In our ITS approach, controller is considering mean speeds of each road side connected to junction and take decision for time duration of green, yellow and red phases for every edge. All junctions are under control of single controller which controls all junctions. All junctions send information to controller after completion of its cycle and controller set the next phases and cycle for particular junction which is an adaptive approach. In short, TLC is using different schedules for different traffic conditions and changing schedules accordingly. In schedules, different states and durations for green, yellow and red phases are defined.

Many simulators are used for implementing various TLC (Traffic Light Control) scenarios such as SUMO (Simulation of Urban Mobility)[6], SiMTram (Simulation of Mixed Traffic Mobility), TraNS (Traffic and Network Simulation Environment) etc. We are using SUMO for simulation purpose as it gives microscopic as well as macro-scopic analysis of traffic.

1.1 Objective of Study

Main objective of study is to increase throughput of multiple traffic light intersections by making traffic light adaptive with the help of ITS. To optimize global road network with vehicular flow information. And also global scheduling of traffic light phases to optimize green phase, make TLC adaptive and optimistic.

1.2 Scope of Work

At initial stage we assume that infrastructure which provides information about all vehicular activity is available to us and perfect for our proposed system. We also consider that all information available to us about traffic flow is accurate. All vehicles strictly follow all traffic instructions and rules given in the designed traffic environment or scenario.

Chapter 2

Literature Survey

2.1 Traffic Light Control

There are three types of TLC used for traffic controlling depending on available infrastructure and traffic environment. There are three types of TLCs: Static, Actuated and Adaptive. Static TLC is having fix timing and fix phase sequence for all phases(green, red, yellow). Actuated TLC is having dynamic timing and fix signal sequence where as Adaptive TLC is having dynamic timing and dynamic signal sequence. In India, most of the traffic signals are having static TLCs. Gradually road transportation system is moving ahead towards using ITS technologies.

2.2 Adaptive Traffic Light Control using WSN

In this approach, Adaptive Traffic Light Control(ATLC) [7] is used in which appropriate architecture is used to collect vehicular information. This information can be used to decide traffic light phase sequence and phase length of red, green and yellow phases. This approach follows following steps[1]:

- Detection of vehicle in the road network
- Determination of sequence for green phase
- Finding phase length

This approach gives better throughput and lesser average waiting time for all vehicles in comparison to fixed time control algorithm(static TLC) and actuated control algorithm(on-line TLC).

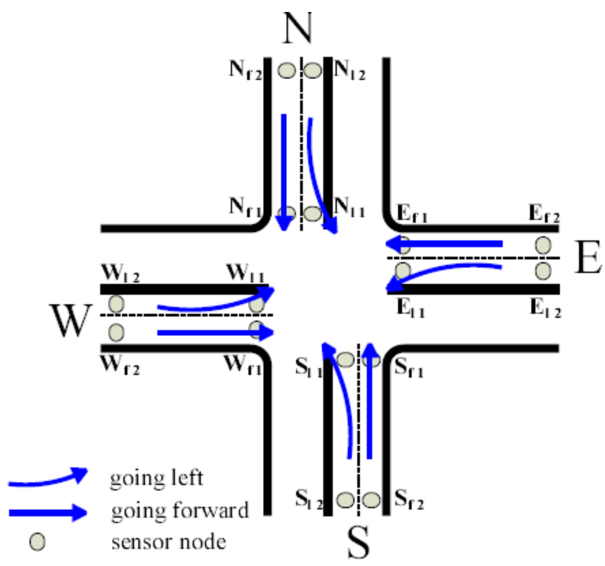

Figure 2.1: Isolated Intersection

In Figure 2.1[1], an isolated intersection is given. It is equipped with sensors and traffic flow can be arrived from four directions: N(north),S(south),E(east) and W(west). There are two lanes on every road side for either turning left or for going in straight direction. There are two phases considered to control all lanes: Red to stop coming vehicles and green to instruct to move ahead to particular lane. In few countries like India, There are three phases: Red, Green and Yellow where Yellow is used to warn vehicles coming to the junction. As shown in the figure, there are sixteen sensors deployed on eight lanes-two sensors per lane for vehicular data collection. These two sensors are deployed: one sensor is deployed near to junction and other at appropriate distance to calculate distance between junction and upcoming vehicles. Here this distance is known as $SensorDistance$[1]. In Figure 2.2[1], for single intersection, twelve possible cases for green phase is given for safety purpose in traffic. So when we use dynamic approach for traffic control, our main aim will be to make a decision that which case will get next green phase and for how much time.

As mentioned earlier, this approach follows following steps[1]: detection of vehicle in the road network, determination of sequence for green phase and finding phase length. In first step, vehicular information gets collected and calculated as per requirements. In second step, next green phase is decided by using vehicular information for most demanding case among all twelve cases. In last step, green phase length is determined according to traffic condition present at particular time for traffic junction.

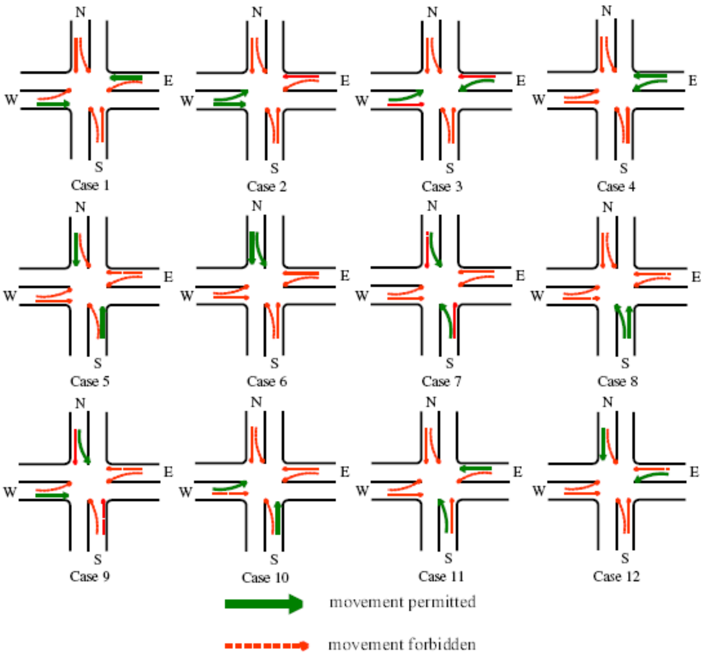

Figure 2.2: Twelve possible configurations of green lights

1. Detection of vehicle in the road network

This step calculates the arrival rate(λ) and departure rate(μ) for all vehicles present in system which can be useful to calculate important data using sensors deployed in road architecture shown in Figure 2.1. This data can be used to calculate total number of vehicles in particular lane, vehicle ID, type and speed of individual vehicles. Arrival rates and departure rates can be calculated. We will discuss arrivals and departure later in section 2.5.

2. Derivation of sequence for green phase

In this step, we derive that which lane will get the next green phase with the help of traffic information collected on real time. Lane with highest demand has more chance to get next green phase by considering few important factors for traffic system like throughput of junction, vehicle density on individual lane as well as on system, average waiting time. Here our aim is to decrease average waiting time and increase throughput. Fairness to every individual lane is also one of the major factor in this approach.

3. finding phase length

In this step, we derive green phase length for particular road side edge. For this much amount of time, vehicles which are in waiting queue are moving towards the junction. When this much time gets completed, Next green phase is to be allocated to another lane and other lanes get other coloured phase according to the above mentioned above from the first step and it is continued until any internal or external interference.

In WSN, there are several sensors such as inductive loop detectors, magnetometer etc. used to generate traffic flow information like vehicle count, waiting time, vehicle speed, vehicle position etc. Wireless magnetic sensors can have less installation and maintenance cost than other detector systems like video, radar and other detectors. Few systems also depends on environmental conditions which effect accuracy of flow information.

We can extend this strategy at multiple intersection level using WSN-based ITS [8].

2.3 Adaptive Traffic Light Control using VANET

Vehicular Ad-Hoc Network (VANET) is a subpart of Mobile Ad-hoc Network. It is widely used for designing intelligent traffic control system. Basically it consists of the mobile nodes, a router unit called as RSU(Road side units),output unit connected and placed within a vehicle called as OBUs(onboard unit),wireless transmission links[9][10].

Output unit/On-Board Units (OBUs): It displays output and provides instruction to the user present in the vehicle. In ad-hoc network, this output device is also used for data transmission or receiving data.

RSU (Road side units): This device works like a router and placed anywhere within the network. It is used to extend the network range. It gives connectivity to all OBUs. It is also used to forward data.

Transmission link: This is a link used to transmit data packet/information with is network. Since it is a wireless link its range can be varied as per the network requirement. Its range can be varied as per the network requirement.

As shown in the Figure 2.3[9], VANET is a group of mobile nodes. Network created using VANET is known as vehicular adhoc network. In this, RSU are placed in particular distance to extend the network and creating a network so that each mobile vehicle can communicate with other mobile node. Here a centralized system is used called as traffic controller which will monitor and control the traffic at the intersection using information transmitted by every vehicle. Optimization of the same is given in [11].

One major requirement for this approach is all vehicles must be fully equipped for more accuracy.

Figure 2.3: Working of VANET environment

2.4 Priority based Traffic Light Controlling

We can assign different priorities to vehicles as per there importance. The lane which is having higher priority vehicles like ambulance or other high priority vehicle will claim higher priority to get green phase first. Emergency vehicles will have lower waiting time and lower response time to be served by TLC compared to other normal vehicles. It is discussed in detail in [12]. SUMO provides facility to assign priorities to different types of vehicles as per requirements.

2.5 Queueing Theory approach for TLC

In Queueing theory, there are two classical types of approaches M/M/1 and D/D/1 used in queueing theory to optimize average waiting time of single intersection [13]. At traffic light signal, according to these classical approaches, there is one single server which is TLC that serves incoming vehicles as per TLC schedule. Generally, In queueing theory process is being served by server. Here we can consider vehicles as processes, server as Traffic Light Controller and road side as queue. All vehicles will be served as First In First Out(FIFO) discipline for single edge. Single server can easily managed using this approach. Major issue in this approach is to synchronize all servers and global scheduling for all of them in such a way that global road network system should be optimized.

Here in M/M/1, first "M" stands for Memoryless arrival time of vehicle, second "M"

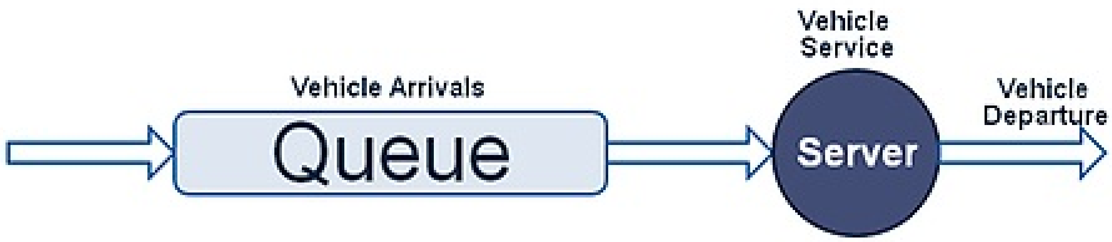

Figure 2.4: Basic Queueing Model used for Road Network

stands for Memoryless service time for arrived vehicle and last "1" stands for single server. Memoryless arrivals and Memoryless service times are random and having Poisson distribution. In D/D/1, first "D" stands for Deterministic arrival time, second "D" stands for deterministic service time and last "1" stands for single server system.

Queueing Model basic notations which can be also be used for road network:

λ = Vehicle arrival rate

W_q =Mean time a vehicle spends in queue

N_q =Number of vehicles in queue

W_s =Mean time a vehicle spends in the system

N_s =Number of vehicles in the system

μ =Vehicle service rate

Arrivals of vehicle and Service to vehicles are basic entities of Queueing Model. There are two types of Queueing Model: single server queueing model and multiple server queueing model. In road network, at particular intersection we can have only one TLC. So for road network single server model is used.

In Figure 2.4, basic queueing model for road network is elaborated. It shows arrival of vehicles to the server, vehicles at road side can be considered as queue. TLC will work as Server. Vehicles which has been served and leaving intersection are departures of vehicles.

2.6 Automated versus Human Traffic Control

In countries which are developing like Dhaka, human traffic controllers proved better than automated traffic controllers. As in developing countries, major changes needed in land management, appliance of automated traffic lights need more maintenance. While human traffic controllers are faster in run time decisions due to their continuous observations its more effective than automated traffic lights and thus automated traffic lights can be more costly for developing countries. It has also been recognized tht human decision making is more effective than micro-processor TLC for decision making[14].

2.7 Earliest-Deadline-Based Scheduling

In this approach, TLC is made adaptive using dead line of intersection. This approach is known as Earliest Dead Line First(EPF) while static approach is known as Fixed Priority(FP) based traffic controlling. Both algorithms are mainly used for traffic lights management. EPF works based on dead line assigned to traffic light intersections. EPF has advantage over FP like low average waiting time, maximum average speed etc [3].

2.8 Conclusion from Literature Survey

All the approaches described in literature survey mainly contains different methods to collect traffic flow information and allocate time phase to traffic signal by using fixed TLC, pre-programmed TLC or dynamic TLC. In country like India, most of the traffic intersection uses fixed TLC. According to requirements, various approaches are taken into account like WSN, VANET, Vehicle-to-Vehicle communication approach to collect vehicular data which can be used to make TLC adaptive. In real life, installation and maintenance cost of these approaches are high and they also depends on many parameters like environmental conditions. For an example, video detection approach can not be used during monsoon and in winter due to fog. Climate also matters in few of these approaches. WSN can be considered as good choice for data collection which can be further proceed in TLC to make decision for adaptiveness.

Table 2.1: Various techniques available for Traffic Light Control

Paper Title	Technique used for Traffic Controlling	Advantages	Disadvantages	Implementation Result
Adaptive Traffic Light Control of Multiple Intersections in WSN-based ITS[8]	Used Wireless Sensor Network for data collection	Easy to detect traffic states, self configurable, easy to exchange information	all vehicles are having constant speed	high throughput, low average waiting time, less number of stops
Adaptive Traffic Light Control Using VANET: A Case Study[10]	Used Vehicular Adhoc Network	1)fixed red phase which can generate more traffic jam issue during less traffic 2)for single intersection	Easy to implement	Improvement in vehicle traffic flow and average waiting time.
Adaptive Traffic Light Control in Wireless Sensor Network-based Intelligent Transportation System[1]	Used WSN based ITS project iSensNet	Easy to exchange information	For single intersection only	Increment in throughput and decrement in average waiting time
A Distributed Algorithm for Adaptive Traffic Lights Control[15]	1)Distributed sensor network 2)Used magnetometers as sensing units	Magnetometer can be better option in terms of cost and efficiency	1)For single intersection only 2)Conflict matrix need to be changed at intersection according to road network design	It distributes overhead costs and easy to establish
Implementation of Adaptive Traffic Light Control System Based on Radio Propagation Model in Vanet[9]	Used direction based propagation function and clustering	Direction oriented clustering algorithm in VANET is good for improving dense traffic conditions	For less traffic it's not useful	Works better during office hours

Paper Title	Technique used for Traffic Controlling	Advantages	Disadvantages	Implementation Result
Shortest Remaining Processing Time Based Schedulers for Reduction of Traffic Congestion[16]	Used Minimum Destination Distance First(MDDF) and Minimum Average Destination Distance First(MADDF) algorithms	Scheduling gives good results	Difficult to implement	Reduced traffic congestion and optimised traffic flow
Earliest-Deadline-Based Scheduling to Reduce Urban Traffic Congestion[3]	Used Earliest Deadline First(EDF) approach and used RFID	Better than Fixed Priority approach	Dependent on reliability of data collected from implemented architecture and	Reduction in congestion
Adaptive Traffic Signal Control With Vehicular Ad hoc Networks[17]	Used Oldest Job First(OJF) algorithm	Good for heavy traffic	Inefficient for less traffic	Gives same result as Webster's method in heavy traffic yet gives lesser delay
Feasibility of Deploying Wireless Sensor Based Road Side Solutions for Intelligent Transportation Systems[18]	Magnetic sensors used for traffic density measurement	Gives better reality based results and easy to detect vehicular flow	Not suitable for road sides which needs more infrastructural changes	Better integrity and feasibility
Modeling the Impact of VANET-Enabled Traffic Lights Control on the Response Time of Emergency Vehicles in Realistic Large-Scale Urban Area[12]	Distance between intersection and emergency vehicles is calculated and considered for allocating green phase	Beneficial for those area where emergency vehicles are required most	Co-ordination of multiple intersection is not implemented	Objective is mainly focused on emergency vehicles

Chapter 3

Existing System

3.1 Static Systems and Dynamic Systems

3.1.1 Static Systems

In static traffic light control system, timings of states and phases are fixed and do not change according to traffic congestion. Thus during normal traffic, this system behaves smoothly and does not have more impact on traffic jam while during heavy traffic, it avoids considering congestion and jam occurs at roads. It also avoids empty roads during traffic control which also affect traffic flow. Such avoidance causes heavy traffic jam [19].

3.1.2 Existing System Approach

Static traffic light control system is using same traffic light logic for traffic junctions which is having same timings for different phases and fixed cycle time.

One of the example of static traffic light logic for existing system is as given below:

```
<tlLogic id="1/1" type="static" programID="0" offset="0">
<phase duration="30" state="GGGGGGrrrrrrrrrrrrrrrr"/>
<phase duration="3" state="yyyyyyrrrrrrrrrrrrrrrr"/>
<phase duration="30" state="rrrrrrGGGGrrrrrrrrrrrr"/>
<phase duration="3" state="rrrrrryyyyrrrrrrrrrrrr"/>
<phase duration="30" state="rrrrrrrrrrGGGGGGrrrrrr"/>
<phase duration="3" state="rrrrrrrrrryyyyyyrrrrrr"/>
<phase duration="30" state="rrrrrrrrrrrrrrrrGGGGGG"/>
<phase duration="3" state="rrrrrrrrrrrrrrrryyyyyy"/>
```

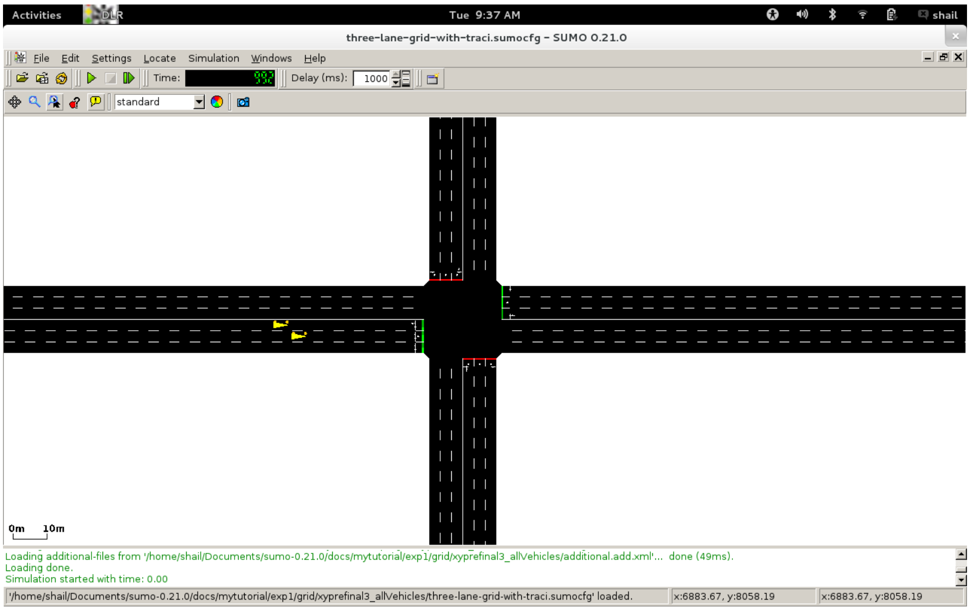

Figure 3.1: Single Isolated Intersection

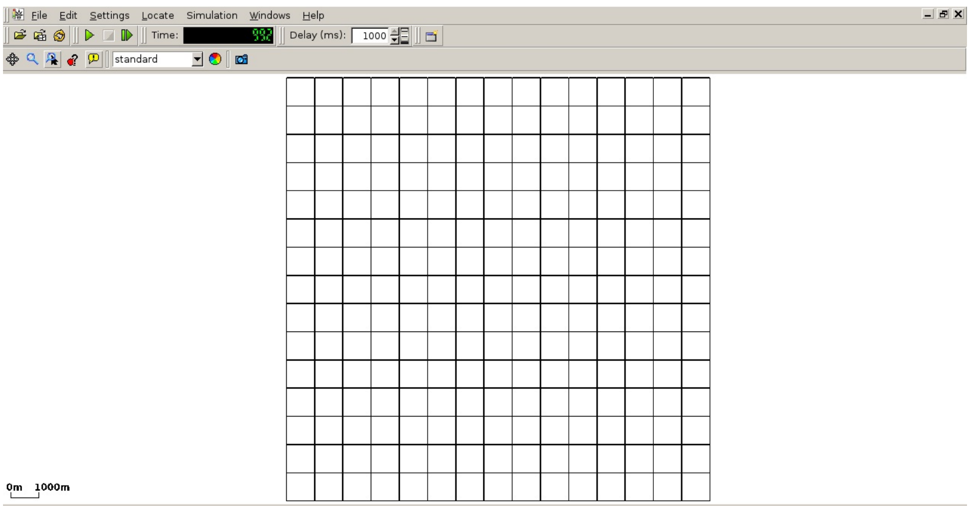

Figure 3.2: Grid road network

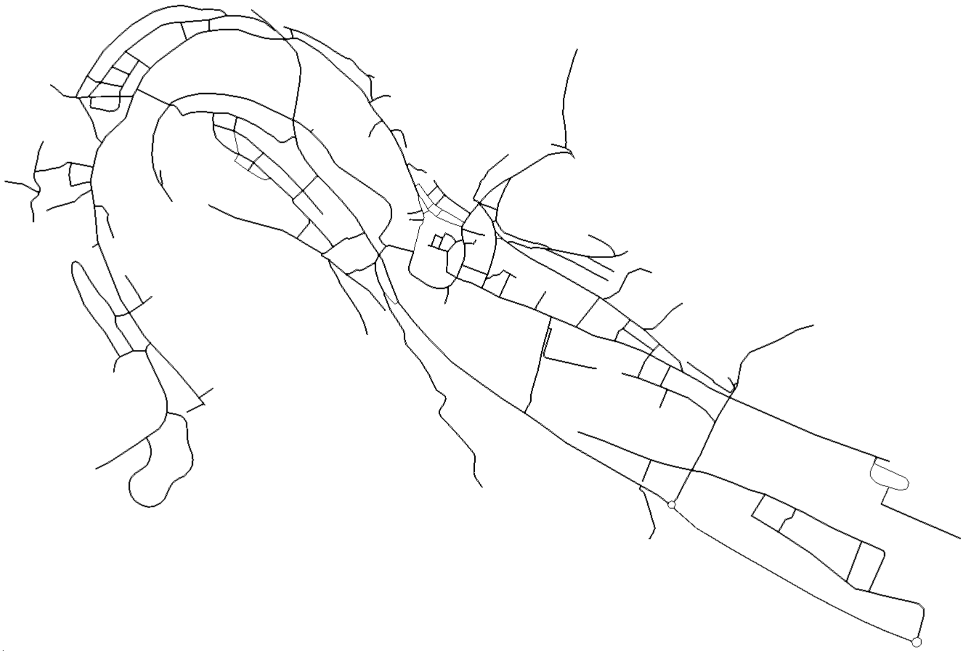

Figure 3.3: Random road network

```
</tlLogic>
```

Here, id="1/1" is traffic light junction, type is type of junction. Phases are different phases of junctions for different lanes where duration is phase duration for that much time traffic phase will hold.
Given traffic light logic is in sequence of North(N), West(W), South(S) and East(E) clock wise manner. Traffic light logic is having GREEN, YELLOW and RED phases. Significance of YELLOW state is to avoid immediate stop of vehicles at junction. If we do not use YELLOW state then vehicles will have immediate stopping and cause collision and trouble. In first phase, 'N' will hold GREEN state for 30 seconds and others will have RED state while in second phase, 'N' will be in YELLOW state for 3 seconds and others will have RED state.

3.2 Dynamic Systems over Static Systems

Dynamic systems have major advantages over static systems.Dynamic traffic light control is also called Adaptive traffic light control. This system basically has functionality of real time reaction on real time traffic data to control and manage low, medium and heavy of traffics. It uses real time traffic data and makes decisions accordingly. It reduces con-

gestion and traffic jam during heavy traffic and considers occupancy of roads. It reduces average waiting time, delay and average trip time for vehicles and road networks which makes this system more effective [19].
Both types of traffic controlling systems can be applied at Single isolated junctions(intersection) and multiple junctions. Multiple junctions can be of two types, grid type of road network and random road network. Single isolated junction is shown in figure3.1, grid road network is shown in figure3.2 and random road network is shown in figure3.3 [6].

Chapter 4

Proposed System

We proposed a new approach to overcome drawbacks of existing static traffic light control systems. Proposed approach is based on parameters collected from available infrastructure. We assume that all data collected is perfect and according to which we are implementing new approach.
In our approach, we are going to use parameters as follows:

- Time step
- Mean speed
- Traffic flow information
- Occupancy

In our approach, we are first collecting road side information from available infrastructures like which vehicle is entering on which road, with how much speed, at how much time, at which road it's going etc. Using these information we are using proposed algorithm to decide how much time should be allocated to which road connected with particular junction and which traffic light phase should be last for how much time. After taking decision for all junctions we apply new traffic light logic for all junctions according to the decision taken by proposed algorithm.

Proposed algorithm is as follows:

Algorithm 1 Proposed Algorithm:

1: Initialize parameters and Cycle time of all junctions to 0
2: Initialize all roads to RED state
3: Compare time step with Cycle time for all junctions
4: **if** Time step equals to Cycle time **then**
5:     Identify number of roads (edges) connected to junction in clockwise manner and all necessary parameters
6:     Compare mean speed of all roads clockwise and decide next traffic light logic for junction
7:     **if** Mean speed of road is less than 5.75 **then**
8:         Asign highest time (say 90 seconds) of GREEN state to all lanes of road and RED state to other roads and assign YELLOW state to all lanes and RED state for particular time (say 3 seconds) in next phase
9:     **end if**
10:     **if** Mean speed of road is great or equal to 5.75 and less than 9.75 **then**
11:         Assign average time (say 60 seconds) of GREEN state to all lanes of road and RED state to other roads and assign YELLOW state to all lanes and RED state for particular time (say 3 seconds) in next phase
12:     **end if**
13:     **if** Mean speed of road is great or equal to 9.75 **then**
14:         Assign lowest time (say 30 seconds) of GREEN state to all lanes of road and RED state to other roads and assign YELLOW state to all lanes and RED state for particular time (say 3 seconds) in next phase
15:     **end if**
16:     Set traffic light logic for junction according to above comparison
17: **end if**
18: Repeat step **(3)** till all junctions get served
19: Go to next time step
20: Repeat steps **(3)**, **(18)** and **(19)** till all vehicles get served

Here in proposed algorithm, in the first step we are initializing all necessary parameters like time step etc. and setting cycle of all junctions to 0.

Second step is most important step of algorithm which is responsible for taking decisions for all traffic light junctions. First of all before applying algorithm, we are initializing all junctions with RED phase. Then we will compare cycle time of all junctions with their cycle time. Here time step is time in second which is increasing in real time. Cycle time is total time allocated to each junction including all phase durations. At the beginning we have allocated 0 cycle time to each junction so when ever we start applying, as per first condition, we will fetch data or parameters of all junctions. Then we will compare mean speed of all roads with thresholds. Here we are using two mean speed thresholds 5.75 and

9.75 and dividing roads in three categories. First category includes those roads which are having mean speed less than 5.75 which will get highest priority and get GREEN phase for 90 seconds, second category includes those roads which are having mean speed great or equal to 5.75 and less than 9.75 which will get the second highest priority and get GREEN phase for 60 seconds after first priority roads if they exists, third category includes those roads which are having mean speed greater than 9.75 which will get the third lower priority than other two and get GREEN phase for 30 seconds after first priority roads and second priority if they exists. These thresholds are decided based on traffic condition for road infrastructure and daily traffic conditions. So these thresholds can be changed accordingly. In our scenario, these two thresholds are perfect for deciding categories as per observations.

We are using three traffic lights GREEN, YELLOW and RED as per Indian scenario. in India, most of the traffic junctions are having 3 or 4 edges. So we applied our algorithm in Grid road network. We have divided roads in 3 categories so if we are taking decision for junction having 4 edges then we will have minimum 81 combinations of traffic logics and if junction has 3 edge then it will have minimum 21 combinations of traffic logics. So we will compare mean speed of all roads connected particular junction and take decision based on 81 logic or 21 logics. All the logics are in such a sequence that the road which is having least mean speed will get GRREN phase first and so on for remaining roads for the same junction. The road which belongs to same category will get green phase in clockwise manner.

After comparison, we will set traffic light logic from 81 logics or 21 logics as per our comparisons so every junction might have different cycle time. We will decide traffic logics for all junctions at a time and then after only we will move forward. When all junctions get served, we will move to next time step and repeat all steps till all vehicles get served by our system.

Here we are basically creating a temporary database of all information necessary for algorithm and use it at each time step. So we can say that our system is working based on the principle of centralized traffic controlling.

Chapter 5

Implementation

We have implemented proposed algorithm in Grid type of multiple intersection road network which is shown in 3.2 in SUMO simulator. We have implemented our algorithm for 2 hours. There are 8400 vehicles in system. We also used Traffic Control Interface (TraCI) and python scripts for implementation.
Here TraCI provides an interface between python script and SUMO simulator to control traffic and to generate and collect data generated by simulator. Following figure 5.1 [3] is the flow chart which describes the role of TraCI to provide interface to simulator SUMO and Python program.

5.1 Simulation

5.1.1 Work done in SUMO

In simulation, we implemented proposed algorithm for pick hours 9 to 11 when traffic is high. We have generated vehicles randomly for those two hours and generation starts at 7200 and ends at 14400. Due to traffic conditions vehicles last in the system for more than two hours.
During simulation we generate network file. Using network file, route file and .sumocfg file we generate information of each vehicles as .xml file. Using that file we generate all useful information like flow information, occupancy of each road, mean speed of each road etc. To process all .xml files we use python scripts. We are generating data of every 10 minutes with updation time of 60 seconds.

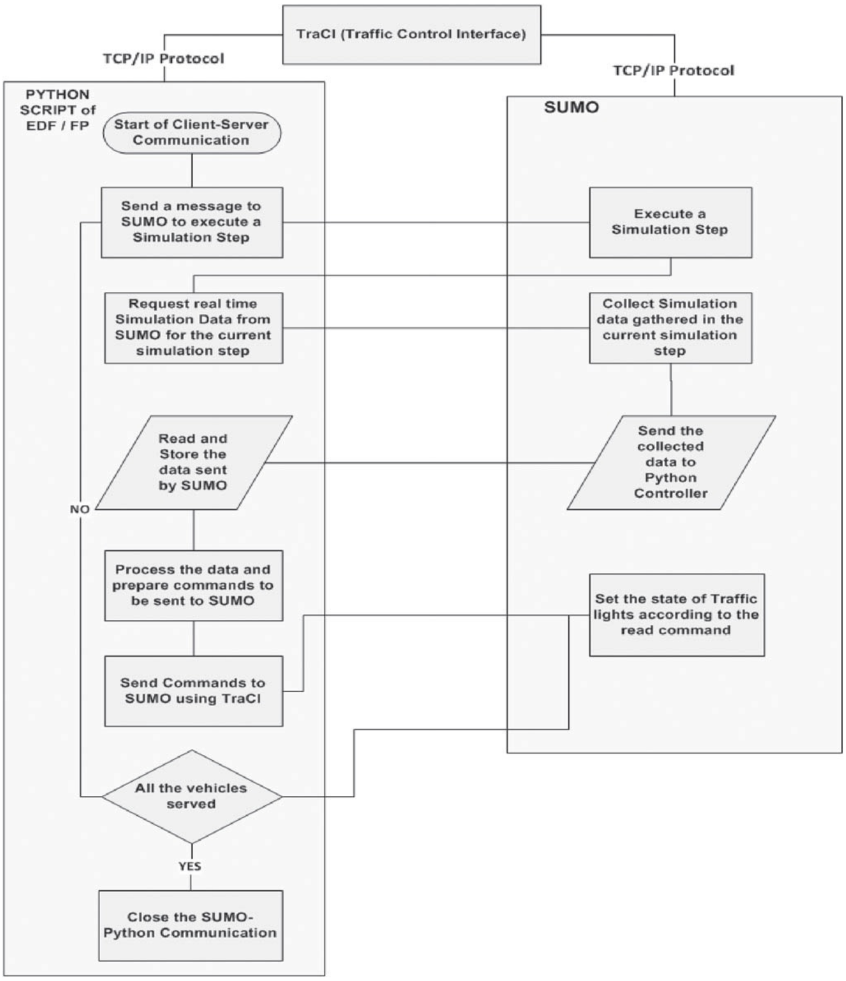

Figure 5.1: Flow diagram describing role of TraCI interface for SUMO and Python program used to control traffic

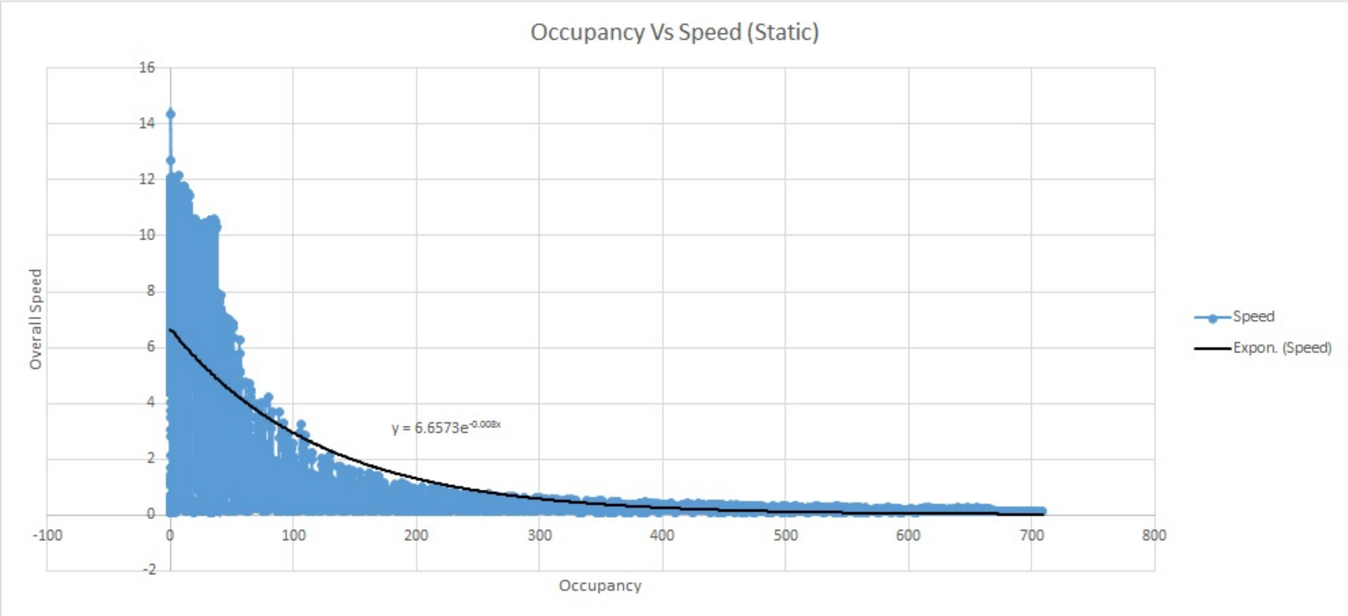

Figure 5.2: Occupancy versus overall speed graph for static traffic light system

5.2 Result and analysis from simulation

For static traffic light system and for dynamic traffic light system vehicles last for different times. Static traffic light system takes more than double time than dynamic system to clear or serve all vehicles. In both the cases, simulation starts at 7200 second. Static system ends at 65140 second while dynamic system ends at 34813 second to clear traffic and to provide service to all vehicles.

We have also analyzed the flow, occupancy and speed. We got this information from output files generated by simulation. Figure 5.2 and Figure 5.3 are the graphs describing the nature of static and dynamic traffic light system with respect to occupancy versus speed.

By comparing both the graphs, we conclude say that static traffic light system occupies higher number of vehicles in roads network than dynamic traffic light system during overall simulation. We can also conclude that dynamic system gives higher overall speed than static system.

Figure 5.4 and Figure 5.5 are the graph for an edge named "0/3to1/3" from road network which shows the effect of making junction dynamic. Figure 5.4 shows that dynamic system has less occupancy than static system with respect to time. Figure 5.5 shows that due to dynamic nature of junction, junction has more flow and due to

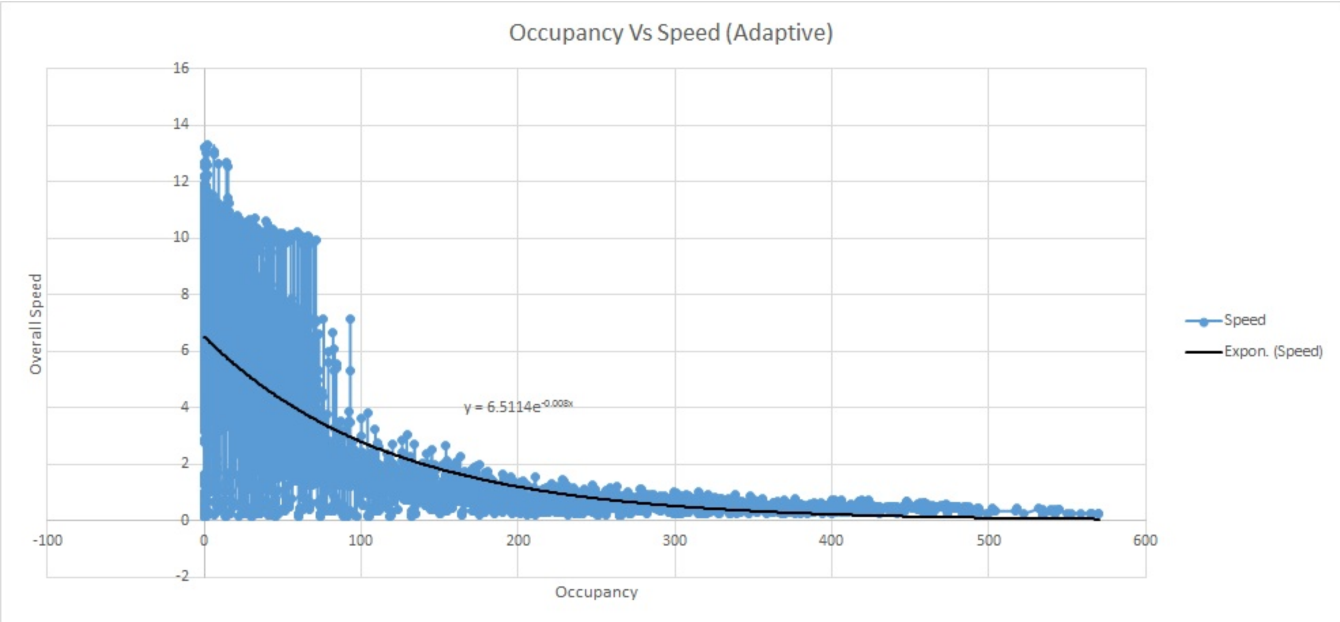

Figure 5.3: Occupancy versus overall speed graph for dynamic traffic light system

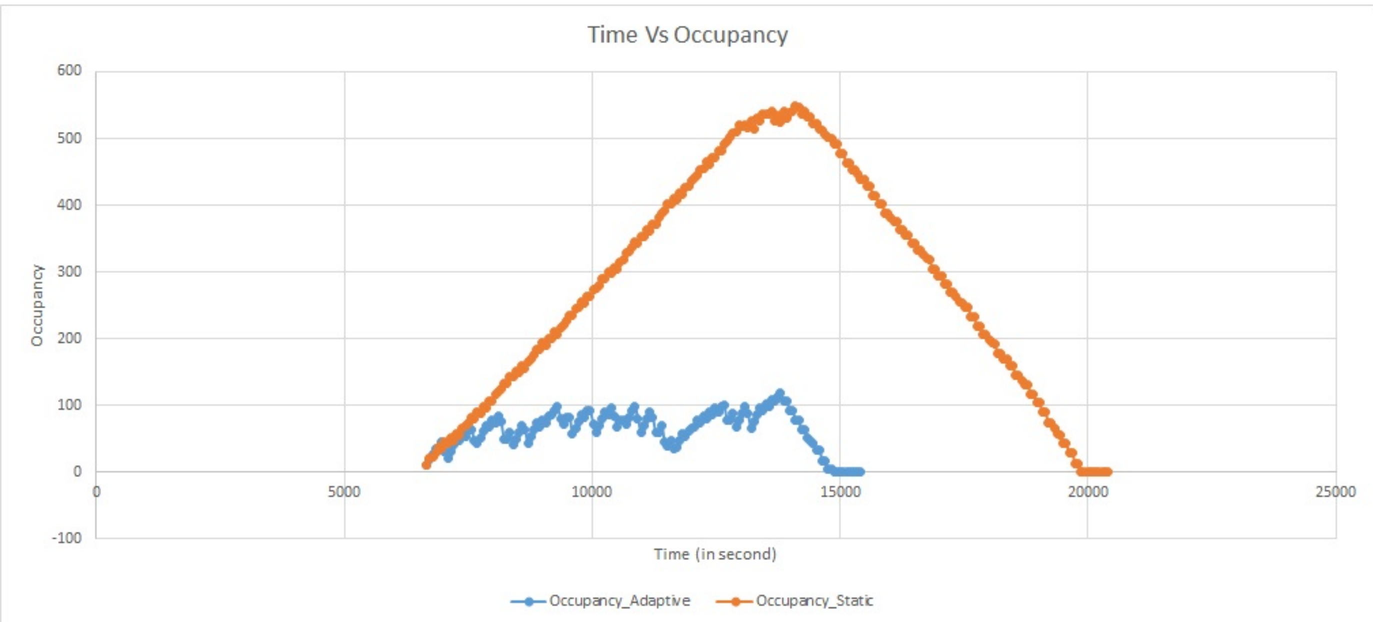

Figure 5.4: Time versus Occupancy graph for an edge "0/3to1/3"

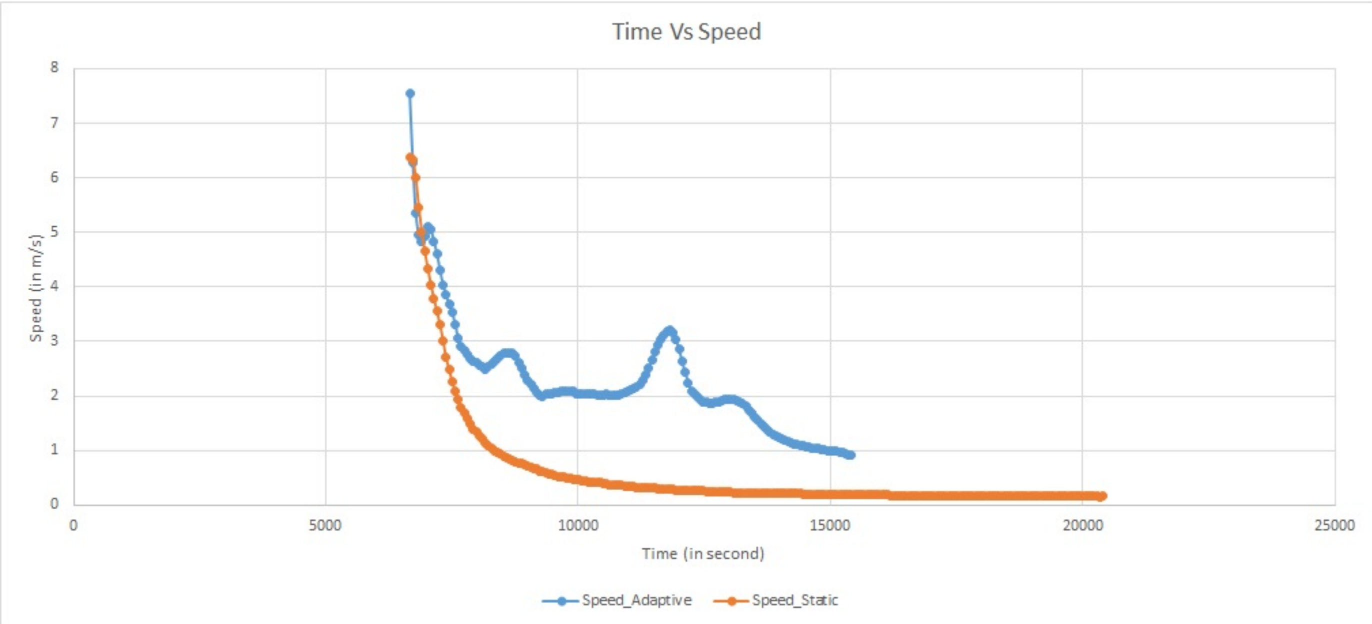

Figure 5.5: Time versus Speed graph for an edge "0/3to1/3"

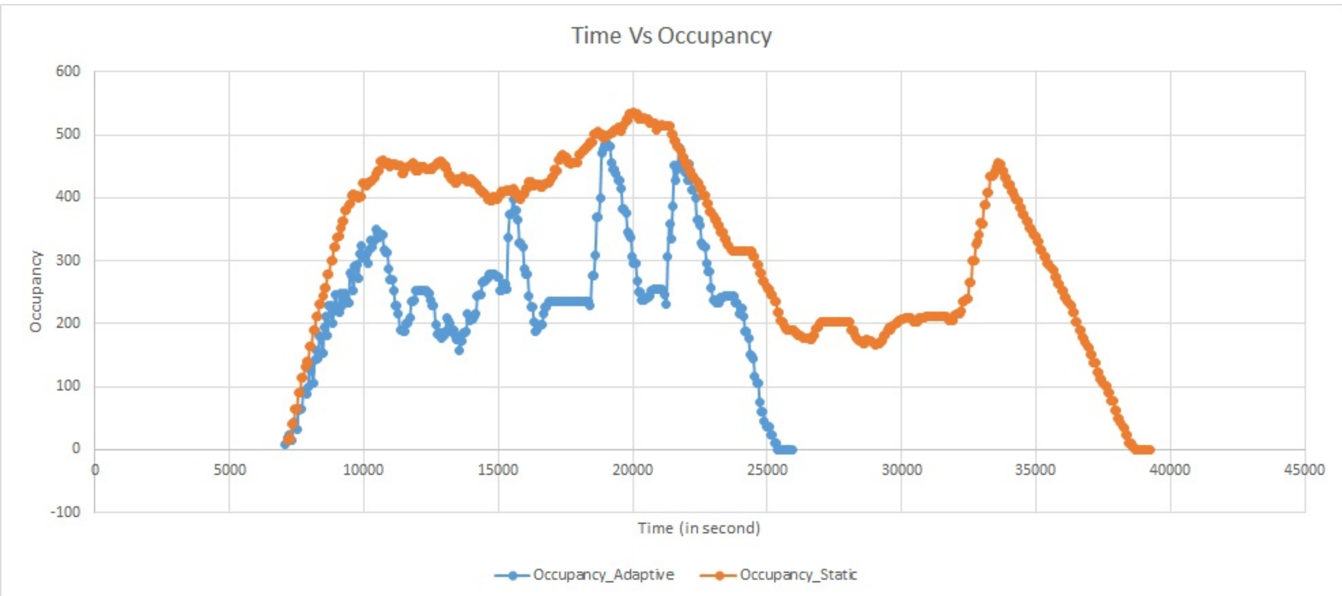

Figure 5.6: Time versus Occupancy graph for an edge "3/4to3/5"

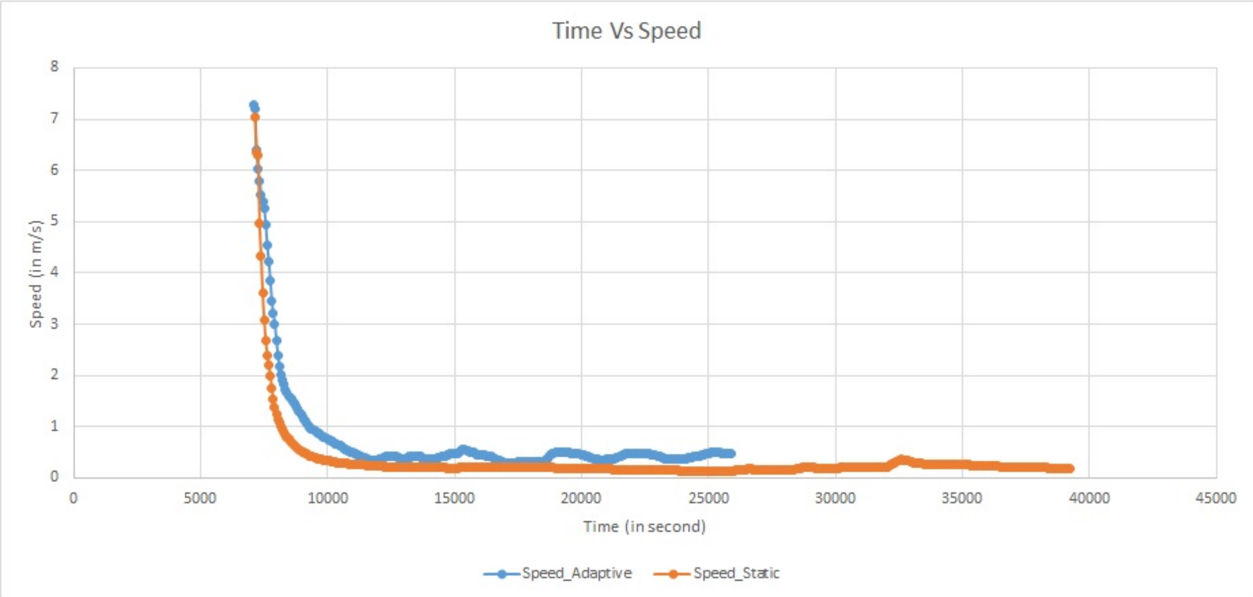

Figure 5.7: Time versus Speed graph for an edge "3/4to3/5"

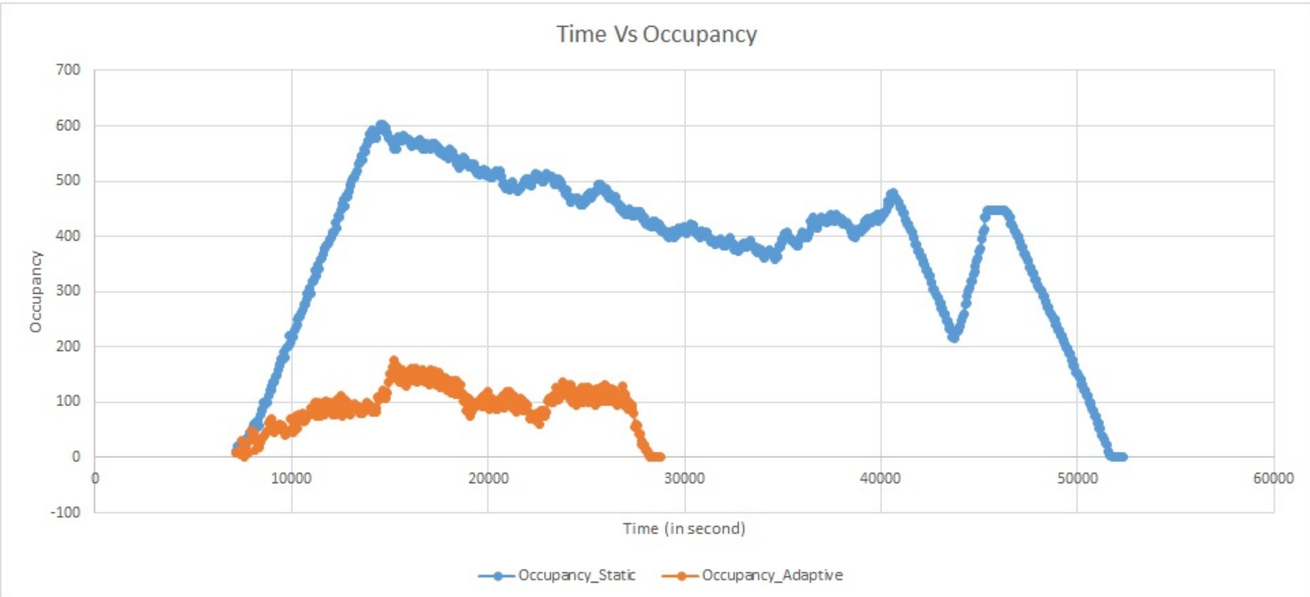

Figure 5.8: Time versus Occupancy graph for an edge "5/5to5/6"

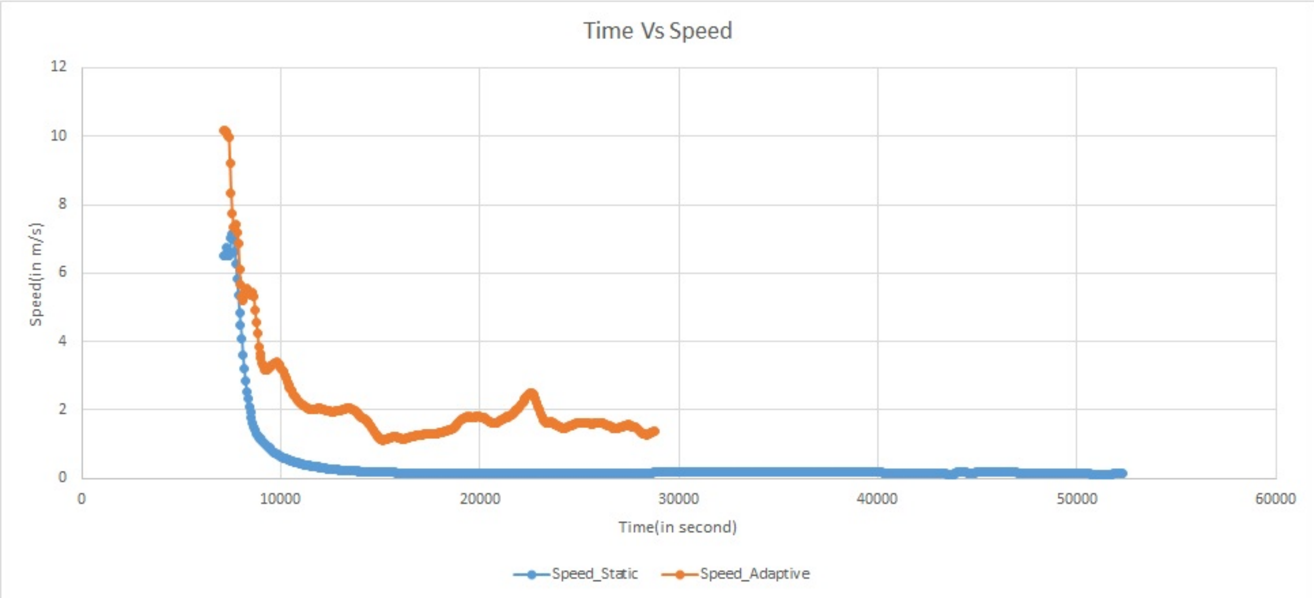

Figure 5.9: Time versus Speed graph for an edge ”5/5to5/6”

which edge has higher speed than static junction with respect to time. Here time is given in seconds and speed is mean speed in meter per second. Same effect and results of adaptiveness are shown for few more edges available in road network. Such edges are represented in Figure 5.6 and Figure 5.7 for edge ”3/4to3/5” and Figure 5.8 and Figure 5.9 for edge ”5/5to5/6” for Time versus Occupancy and Time versus Speed respectively.

Chapter 6

Conclusion and Future Scope

6.1 Conclusion

Approach used for static traffic lights are mostly used as isolated approach. It can also be used as centralized way but it is more costlier than isolated approach for static traffic lights. Our proposed approach is applied as centralized approach which takes care of all junction at a time. It checks whether any updation requires for particular junction or not and updates information if there is any updation for particular junction. So it takes care of multiple junctions for traffic controlling. Proposed algorithm is dynamic or dynamic in nature. Proposed approach takes decision for phase durations according to traffic condition at particular junction. For every junctions it defines the priority and according to priority, it gives GREEN phase to roads.

From the results we can conclude that proposed algorithm for adaptive traffic light system works better than existing static traffic light system. It increases the overall speed of road network, decreases overall trip time of all vehicles and also decreases the occupancy of roads and traffic jam at junctions in road network. It increases the flow at each junction. Due to these factors, we are able to serve all vehicles faster and clear traffic faster than static traffic light system by using proposed algorithm.

6.2 Future Scope

By considering more number of parameters and traffic conditions like empty lanes, pedestrian traffic etc, we can increase efficiency and utilization of traffic light controllers. With increment of more condition in our proposed approach, number of traffic light control will increase. For road network like random road networks, more conditions should be included to make our approach more effective. In proposed approach we have used local information for decision making while global information can also be used for the same approach.

References

[1] B. Zhou, J. Cao, X. Zeng, and H. Wu, "Adaptive traffic light control in wireless sensor network-based intelligent transportation system," in *Vehicular Technology Conference Fall (VTC 2010-Fall), 2010 IEEE 72nd*, pp. 1–5, IEEE, 2010.

[2] M. Tubaishat, Y. Shang, and H. Shi, "Adaptive traffic light control with wireless sensor networks," in *Proceedings of IEEE Consumer Communications and Networking Conference*, pp. 187–191, 2007.

[3] A. Ahmad, R. Arshad, S. A. Mahmud, G. M. Khan, and H. S. Al-Raweshidy, "Earliest-deadline-based scheduling to reduce urban traffic congestion," 2014.

[4] F. Daneshfar, F. Akhlaghian, and F. Mansoori, "Adaptive and cooperative multi-agent fuzzy system architecture," in *Computer Conference, 2009. CSICC 2009. 14th International CSI*, pp. 30–34, IEEE, 2009.

[5] A. Ahmed, R. Arshad, S. A. Mahmud, G. M. Khan, and H. Al-Raweshidy, "Evaluation of earliest deadline based schedulers for reduction of traffic congestion in dense urban areas," in *Connected Vehicles and Expo (ICCVE), 2013 International Conference on*, pp. 404–409, IEEE, 2013.

[6] *http://www.dlr.de/*. accessed on : 2014-07-01.

[7] M. Tubaishat, Y. Shang, and H. Shi, "Adaptive traffic light control with wireless sensor networks," in *Proceedings of IEEE Consumer Communications and Networking Conference*, pp. 187–191, 2007.

[8] B. Zhou, J. Cao, and H. Wu, "Adaptive traffic light control of multiple intersections in wsn-based its," in *Vehicular Technology Conference (VTC Spring), 2011 IEEE 73rd*, pp. 1–5, IEEE, 2011.

[9] S. Dorle and P. Patel, "Implementation of adaptive traffic light control system based on radio propagation model in vanet," in *Electric Vehicle Conference (IEVC), 2013 IEEE International*, pp. 1–5, IEEE, 2013.

[10] S. Kwatirayo, J. Almhana, and Z. Liu, "Adaptive traffic light control using vanet: A case study," in *Wireless Communications and Mobile Computing Conference (IWCMC), 2013 9th International*, pp. 752–757, IEEE, 2013.

[11] S. Kwatirayo, J. Almhana, and Z. Liu, "Optimizing intersection traffic flow using vanet," in *Sensor, Mesh and Ad Hoc Communications and Networks (SECON), 2013 10th Annual IEEE Communications Society Conference on*, pp. 260–262, IEEE, 2013.

[12] H. Noori, "Modeling the impact of vanet-enabled traffic lights control on the response time of emergency vehicles in realistic large-scale urban area," in *Communications Workshops (ICC), 2013 IEEE International Conference on*, pp. 526–531, IEEE, 2013.

[13] P. Chanloha, W. Usaha, J. Chinrungrueng, and C. Aswakul, "Performance comparison between queueing theoretical optimality and q-learning approach for intersection traffic signal control," in *Computational Intelligence, Modelling and Simulation (CIMSiM), 2012 Fourth International Conference on*, pp. 172–177, IEEE, 2012.

[14] S. Khan, "Automated versus human traffic control for dhaka and cities of developing nations," in *Computer and information technology, 2007. iccit 2007. 10th international conference on*, pp. 1–4, IEEE, 2007.

[15] I. D. Sebastien Faye, Claude Chaudet, "A distributed algorithm for adaptive traffic lights control," 15th International IEEE Conference on Intelligent Transportation Systems, 2012.

[16] G. M. K. F. Z. Y. Fawad Ahmad, Sahibzada Ali Mahmud, "Shortest remaining processing time based schedulers for reduction of traffic congestion," International Conference on Connected Vehicles and Expo (ICCVE), 2013.

[17] D. G. Kartik Pandit, "Adaptive traffic signal control with vehicular ad hoc networks," IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, 2013.

[18] H. A. S. A. M. G. M. K. Fawad Ahmad, Abdul Basit and F. Z. Yousaf, "Feasibility of deploying wireless sensor based road side solutions for intelligent transportation systems," International Conference on Connected Vehicles and Expo (ICCVE), 2013.

[19] P. L. Patel and S. Dorle, "Design approach for adaptive traffic light control system based on radio propagation model in vanet," in *Communication Systems and Network Technologies (CSNT), 2013 International Conference on*, pp. 268–271, IEEE, 2013.