VEHICULAR COMMUNICATION SYSTEM FOR REDUCING FUEL COST AND EMISSION

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*Abstract:*Nowadays, the number of vehicles on the road and the need of transporting people grow fast. Road transportation has become the backbone of industrialized countries. As a consequence, themodern society is facing more traffic jams, higher fuel bills and high levels of CO_2 emissions.Vehicular communication networks are increasingly being considered as a means to conservefuel and reduce emissions within transportation systems. This paper focuses on using traffic light signals to communicate with the approaching vehicles. Thecommunication can be traffic-light-signal-to-vehicle and vehicle-to-vehicle communication. Based on the information sent, the vehicle receiving the message adapts its speed to a recommended speed, which helps the vehicle reduce fuel consumption and emissions.

***Index Terms*–Vehicular communication, fuel cost, emission.**

I. INTRODUCTION

These days the detrimental effects of air pollutants and concerns about global warming arebeing increasingly reported by themedia. In many countries, fuel prices have been risingconsiderably. The U.S. Environmental Protection Agency (EPA) ranks the transportation sector,among all end-user sectors, as the second largest contributor to greenhouse gas (GHG) emission,which may have profound negative impact on the global climate. Within the transportation sector,vehicles that we drive release more than 1.7 billion tons of CO2 into the atmosphere each yearalone. The vehicular carbon footprint is a measure of the vehicle's environmental impact onclimate change in terms of CO2 emission, which also has a direct relationship with the fuelconsumption of vehicles. As economic growth provides sustaining demands for fossil fuels, theproblem of how to reduce vehicular carbon footprint and fuel consumption becomes not only anenvironmental problem but an economic problem as well. Among all factors that determine the fuel efficiency of an individual vehicle, the impact of speed and acceleration/deceleration issimilar among all vehicles.

II. LITERATURE SURVEY

Vehicle traffic congestion leads to air pollution, driver frustration, and costs billions of dollarsannually in fuel consumption. Finding a proper solution to vehicle congestion is a considerablechallenge due to the dynamic and unpredictable nature of the network topology of vehicularenvironments, especially in urban areas. Vehicle Traffic Routing Systems (VTRSs) are one of themost significant solutions for this problem. Although most of the existing VTRSs obtainedpromising results for reducing travel time or improving traffic flow, they cannot guarantee reductionof the traffic-related nuisances such as air pollution, noise, and fuel consumption [1]. Within the context of sustainable development, reducing fuel consumption and travel times are an essential part of our daily life. The efficiency of a speed advisory algorithm was tested in [2]. The performance of the evaluated algorithm was compared to two other scenarios: in the first, participants drove freely through the intersection; in the second, participants received the time remaining for the current red signal indication via I2V communication.I2V communication helps reduce vehicle fuel consumption and travel time in the vicinity of signalized intersections.Thedegree of benefits provided by this communication depends on the type of the information sent.A bottom–up vehicle emission model has been proposed to estimate real-time CO2 emissions using ITS technologies in [3]. In the proposed model, the road segment was adopted as a basic spatial unit to estimate CO2 emissions to explicitly consider the effects of heterogeneous speeds within the road link. The GPS and loop detector data that were collected by ITS applications were employed to generate detailed vehicle technology and driving patterns for all vehicles in the road network. The low-frequent GPS data were matched onto the road network and interpolated into second-by-second speed profiles to calculate the vehicle driving pattern data for each road segment. The traffic flow data that were collected by loop detectors were processed to calculate the vehicle kilometers traveled data for each road segment and to estimate the vehicle technology data based on the identified vehicle-type data. Based on these calculated detailed vehicle technology and driving pattern data, the CO2 emissions were estimated using the IVE model.

III. PROBLEM STATEMENT

Nowadays, the number of vehicles on the road and the need of transporting people growfast. Road transportation has become the backbone of industrialized countries. Nevertheless, theroad network system in cities is not sufficient to cope with the current demands due to the size of roads available. Building additional or extending existing roads do not solve the traffic congestion problemdue to the high costs and the environmental and geographical limitations. As a consequence, themodern society is facing more traffic jams, higher fuel bills and high levels of CO2 emissions. Vehicular communication networks are increasingly being considered as a means toconserve fuel and reduce emissions within transportation systems. This paper focuses on usingtraffic light signals to communicate with approaching vehicles. The communication can be trafficlight-signal-to-vehicleand vehicle-to-vehicle. Based on the information sent, thevehicle receiving the message adapts its speed to a recommended speed, which helps thevehicle reduce fuel consumption and emissions. The objective is to minimize fuelconsumption by and emissions from vehicles.

IV. DESIGN

Thenodes in the road network are 1) mobile: vehicles and 2) fixed: Traffic Light Signals.Wireless communications consist of Vehicle to Vehiclecommunication and Traffic Light Signal to Vehicle communications. Therefore, Traffic Light Signals andvehicles are assumed to be equipped with an onboard unit, which is an entity that is responsible forvehicular communication, such as wireless radio access and geographical ad hoc routing. Vehiclesare also equipped with an application unit, which is an entity that runs applications. It isassumed that the application units are equipped with highly accurate position data and an electronic road map. Therefore, vehicles know their locations and the locations of Traffic Light Signals. Vehicles periodicallyexchange their (X,Y) location coordinates.
Traffic Model Street segments with length L, N lanes, maximum speed limit (Smax), andminimum speed limit (Smin) have been considered. Traffic Light Signals are placed at intersections; twocategories of consecutive intersections exist:

- Those with coordinated systems, with Traffic Light Signals timed so that traveling vehicles need not stop at eachintersection.
- Isolated intersections, which are not close to each other and are independent

Traffic Light Signal controllers can be static or dynamic. Static Traffic Light Signals are controlled by fixed cycle controllers, regardless of the current traffic volume. In contrast, the operation of dynamic Traffic Light Signalcontrollers varies, based on the observed traffic volume. Here, we consider a predominantly Traffic Light Signalmodel, where Traffic Light Signals have three phases, namely, green “g,” yellow “y,” and red “r,” whose durations are fixed.Other Traffic Light Signal models, such as flashing and arrowsignals, can be incorporated into the predominant model. Vehicle traffic mobility is based on thecar-following concept. We use the car-following behavior that has been used in the well-knowntraffic simulator called integration. The movements of the vehicles are adapted according tothe space headway. Vehicles travel at the free-flow speed. Each vehicle estimates the spaceheadway between itself and a vehicle driving ahead of it (its leader) or the space headway betweenitself and a red or yellow TLS. When this space headway reaches the minimum safe spaceheadway (hmin), the vehicle has to be decelerated. hmin is calculated as the time a vehicle has tocomfortably decelerate from its current speed to the speed of its leader multiplied by the averagespeed of the vehicle and its leader.

The traffic signal contains Traffic light program with automatic switching tored and green lights with 5 sec yellow period. It can be implemented by using timer interruptand timer ISR. LED/Bulbs are driven by high current ULN2003 driver which contains Darlingtonpairs.

This part is to be fitted in cars or vehicles, its job is to receive and broadcasted traffic signal statusand time using wireless interface and display the current signal stateto the driver so that even there is any vehicle in front or far from signal or its foggy still it will be possible to see the signal state on a personal display. For this communication driver should be implemented in code and wireinterface is established. This is shown in Fig 4.1.

Next is to find the location of the vehicle from the GPS, GPS gives the latitude and longitude serially via TTL UART we receive it then extract the position information. Using this position information and traffic signal id we can find the distance of vehicle from traffic signal, there is look up table to find location of traffic signal from it. This is shown in Fig 4.2.

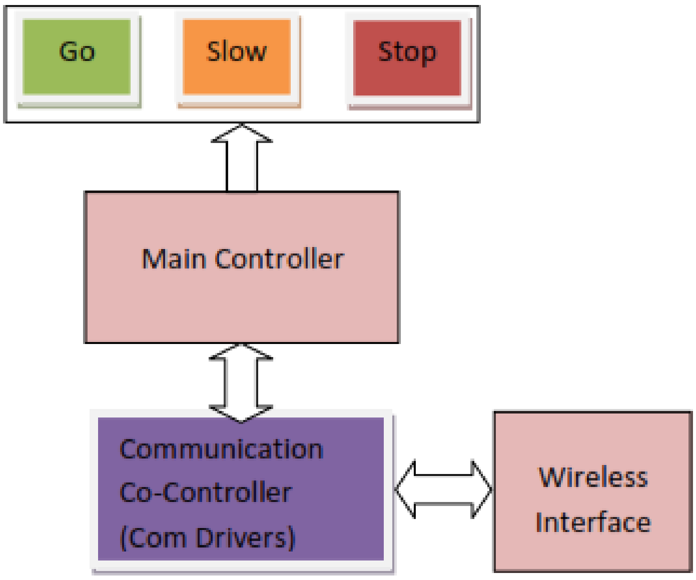

Fig 4.1 Block Diagram of TLS X1

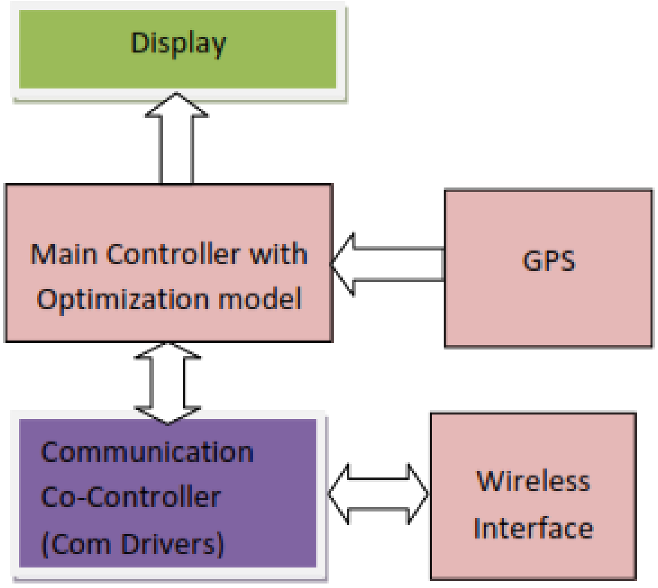

Fig 4.2 Block Diagram of a Vehicle X 2

The kinds of communications that occur in this system model are

From a Traffic Light Signal to vehicles: A Traffic Light Signal sends a packet to the first vehicle in each lane inside ROI1.The packet contains the following information:

- The type of the current phase;
- The time remaining to switch from the current phase;
- The Traffic Light Signal schedule; and
- The geographical address of the destination node, which is the first vehicle in each lane.

Since a Traffic Light Signal communication range covers the entire lane or part of it, the Traffic Light Signal can sense (X,Y) coordinatesfrom vehicles inside its coverage. Therefore, a Traffic Light Signal can know the location of the first vehicle in each lane. Since each vehicle knows its own location, a vehicle can recognize itselfwhether it is the destination node or not. A vehicle discards the packet if it is not the destinationnode. Otherwise, the vehicle calculates and adjusts its speed to the optimum speed, which isdetermined using our optimization model.

Inter vehicle communication: As discussed in the first case, the Traffic Light Signal sends the information to thefirst approachingvehicle in each lane. The vehicle then calculates and adjusts its speed tothe speed which isdetermined using our optimization model. Next,Vehicle 1(V1) unicasts a packet to the vehicle behind it (following) on the same lane (V2),which contains its (V1's) speed determined by the optimization model and stopping time at the Traffic Light Signal and that vehicle's (V2's) geographical location and the Traffic Light Signalschedule. V2 receives the packet if it is within the V1 transmission range. Based on the packetinformation, V2 calculates and adjusts its speed to the speed determined by the optimization model. The same approach is repeated to the vehicle behind it (e.g., V3). In this case, V2 becomes theleader, and V3 is the follower.

V. RESULTS AND DISCUSSIONS

```
TS lat:13.1337 long:77.5715
Veh lat:13.1335 long:77.5674
Distance to TS: 457.0
Signal=RED Dur=60 dist:457.0
Smin=5.6 Smax=16.7
tmin=27.4 tmax=82.3
*2
Speed=6.5 m/s dist1:391.7
Speed=23.5 Km/hr
Total Time=70.0
```

```
Input >>
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
```

Fig. 5.1 Test Case Screen Shot 1

```
TS lat:13.1337 long:77.5715
Veh lat:13.1335 long:77.5674
Distance to TS: 457.0
Signal=GREEN Dur=59 dist:457.0
Smin=5.6 Smax=16.7
tmin=27.4 tmax=82.3
^2
Speed=9.3 m/s dist1:550.3
Speed=33.6 Km/hr
Total Time=49.0
```

```
Input >>
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
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$GPRMC,174405.001,A,1308.0098,N,07734.0435,E,000.0,290.3,070418,,,A*65 //BSMIT APR18
```

Fig. 5.2 Test Case Screen Shot 2

Below gives the table of all the test cases being carried out on the system for testing.

Sl. No	Input	Expected Output	Results
1.	$GPRMC,174405.001,A,1308.0368,N,07734.0809,E,000.0,290.3,070417,,,A*65	Signal=GREEN Dur=58 dist:347.2 Smin=5.6 Smax=16.7 tmin=20.8 tmax=62.5 ^2 Speed=6.0 m/s dist1:347.2 Speed=21.6 Km/hr Total Time=58.0	Pass
2.	$GPRMC,174405.001,A,1308.0368,N,07734.0809,E,000.0,290.3,070417,,,A*65	Signal=GREEN Dur=18 dist:347.2 Smin=5.6 Smax=16.7 tmin=20.8 tmax=62.5 ^3 Speed=5.6 m/s dist1:100.0 Speed=20.0 Km/hr Total Time=62.5	Pass
3.	$GPRMC,174405.001,A,1308.0368,N,07734.0809,E,000.0,290.3,070417,,,A*65	Signal=RED Dur=36 dist:347.2 Smin=5.6 Smax=16.7 tmin=20.8 tmax=62.5 *2 Speed=8.5 m/s dist1:304.9 Speed=30.5 Km/hr Total Time=41.0	Pass

VI. CONCLUSION

A comprehensive optimization model for Vehicle to Vehicle and Traffic Light Signalto Vehicle communication is implemented with the objective of minimizing fuel consumption by controlling emissions from vehicles approaching a Traffic Light Signal. It helps vehicles to avoid having to stop, make lengthy accelerations, and run at unnecessarily excessive speed. In this paper, we have designed an independent traffic controller system which is fully automatic and designed as per traffic rules. Not only it is automatic traffic control system it has smart vehicle communication module which broadcasts its id, signal type/state and duration to the following vehicles. These vehicles use this information and calculate the recommended speed to save fuel and reduce emission.

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