MRGM: An Adaptive Mechanism for Congestion Control in Smart Vehicular Network

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***Abstract*:** Traffic flow on roads has increased manifolds from past few decades due to increase in number of vehicles and rise in population. With fixed road infrastructure and more vehicles on traffic routes lead to traffic congestion conditions especially in urban areas of developing nations. Traffic jams are normal in major cities which ultimately cause delay in travel time, more fuel consumption and more pollution. This manuscript propose a Multi-metric road guidance mechanism (MRGM) which considers multiple metrics to analyze the traffic congestion conditions and based on the conditions effective optimal routes are suggested to the vehicles. The Simulation of the proposed mechanism is performed with the SUMO by using the python script and the results show that proposed mechanism i.e. MRGM outperforms other mechanism in terms of traffic efficiency, travel time, fuel consumption and pollution levels in the smart vehicular network.

***Keywords*:** Smart vehicular networks, Guidance systems, Multi-metric parameters, Vehicle congestion index and vehicle congestion density.

1. Introduction

With the growth of the economy of various developing and developed nations and continuous rise in urban population, the demand for road travel has increased from the past few decades. The number of vehicles on the roads has been increased exponentially. With this, the traffic jams and accidents have also been increased. According to the Global status report on road safety 2018 by the World Health Organization [1], the number of road accident death has-been reached to 1.35 million on annual basis. There has been no reduction in the number of traffic accidents in low income countries since 2013. According to the urban mobility report 2019[2] the estimated value of travel time delay is 18.12 dollars per hour of a person travel in US which is the congestion cost. With this, there is increased fuel consumption due to travel in congestion conditions. ITS which is also called an intelligent transportation systems provides new and innovative services related to traffic management system in order to reduce the travel time of vehicles, makes transportation safe ,more coordinated and smarter use of transportation networks. There are various applications of intelligent transport system like collection of real time traffic information, safety improvements in terms of travel on roads and intelligent route guidance system. The intelligent route guidance systems play the crucial role in terms of finding the optimal route to the vehicles so that vehicles can avoid the congestion paths and it will also reduce the travel time for the vehicles. In smart cities, real time traffic surveillance is an intrinsic part of intelligent transportation systems. The real time information of vehicles is collected through the GPS coordinates and through the sensors. The vehicles are arranged in the form of clusters and the vehicle which is closer to the center of the cluster is called as the cluster head which is responsible for collecting the information of the cluster and sharing it with the neighboring clusters. In this way, the information is propagated throughout the vehicular network. When a vehicle receives the traffic information, then a trust based mechanism runs which predicts the traffic density of current guide route with the threshold value. If the predicted traffic density of the current route is greater than the threshold value then the mechanism will recommend the alternate route [3].

The traffic path guidance system can be classified into categories: a) Static guidance system b) Dynamic guidance system. In a static route guidance system, the fixed data information of traffic is collected over a specified period of time [4-6]. This category poses a problem when dealing with real time traffic information. A more robust solution is a dynamic guidance system where real time information is collected from vehicles and sensor nodes alongside the road in order to detect the traffic congestion [7]. Dynamic guidance system can be further classified into the following categories: a) Centralized b) Distributed c) Semi distributed.

In the centralized system, the main server system is responsible for collecting the information of all the traffic conditions [8]. The main challenge with the centralized system is when traffic data increases, its performance decreases due to the high computational power requirement and high computational load exchange. Further, there is a delay in exchange of information between the vehicles and server which makes this system difficult for large road networks. On the contrary, in the distributed system, there is no fixed infrastructure and each vehicle acts as a node which is responsible for simultaneously receiving as well as sending the information to other nodes (E.g. vehicle to vehicle communication in VANET)[9],[10]. The high computational processing of information is shared between the vehicular nodes means this system requires less computational power. Distributed system has found to have less delay while sharing of information but this system has the limited knowledge of general traffic conditions. So, under the traffic congestion, it may provide same traffic route to several vehicles coming from various directions which results in congestion again on new route. The semi distributed system has the capability of both centralized and distributed system which solves the issue of delay enigma of centralized system and global view problem of distributed system [11]. After the congestion is detected, the next step is to find the optimal route for the vehicles in order to manage the traffic effectively. For this the route guidance system has been categorized into the single metric and multi metric parameters in order to calculate the optimal route for the vehicles. The single cost metric uses one parameter which is travel time of vehicle in order to find the optimal route. But in real world traffic scenario, multi metric parameters like travel time, width of vehicles, size of the road, length of the road etc. are required in order to get a better picture of the traffic on the roads. With the improvement in the real time data collection, high computational power and multi metric route guidance system has come up with the better ways for the traffic management under the different conditions. Advancement in the technologies likes cloud computing, fog computing and Data analytics, the analysis of traffic conditions has now become easy and effective in terms of managing the vehicle traffic environment.

Most of the research on the route guidance system has focused on detecting the congestion and finding the optimal route for the vehicles which leads to the other congestion scenarios. For example, Let us take a scenario in which many roads are blocked due to congestion, then re-routing mechanism will guide the vehicles to the neighboring road due to which the congestion on the neighboring road will also increase as althea vehicles are then routed to the same route which leads to another traffic problem. In order to solve the above problem, this proposed work focuses on developing adaptive routing mechanism which will provide an effective traffic management solution. First of all, the traffic congestion is detected by using multi metric parameters. In this various factors are going to be considered in order to find congestion conditions like size of road, width of a vehicle, travel time of vehicle etc. In this routing mechanism, the traffic congestion is divided into two three categories: a) High congestion) Moderate Congestion) Low congestion. Based on the type of congestion, there are backward or alternate routes which will guide the traffic on neighboring routes. This proposed mechanism ensures that in case of traffic congestion conditions, all the vehicles should not be routed towards the same alternate route. MRGM congestion control mechanism makes sure to find the optimal route for the vehicles and it reduces the overall congestion in the whole network of roads in a particular geographical location. In this Vehicle Congestion Density (VCD) function has been proposed which will define congestion according to traffic states and then corrective measures to avoid the congestion. This mechanism ensures that on alternate or backward route if traffic congestion occurs, then find other optimal routes for vehicles. The structure of the paper is as follows: Section 1: Introduction to the Traffic management system and issues related to it. Section 2: It describes the work related to traffic management systems and various techniques and mechanisms that have worked on traffic related issues. Section 3: The system architecture proposed traffic congestion control mechanism is described in this section. Section 4: This section introduces the proposed methodology and algorithm for this research. Section 5: Simulation results of proposed work and comparison results with existing mechanisms like RGS Refocus and SSRGS are presented. Section 6: This section discussed the conclusion in which it has mentioned how the proposed mechanism outperforms existing mechanism in terms of traffic efficiency, travel time, fuel consumption and pollution levels in the smart vehicular network.

2. Related work

In past works that have been done on various algorithms for congestion detection and avoidance. The system enables the counting & classification of the vehicles in the particular direction, which can easily pave the way for more smart vehicular traffic management across the urban areas to decongest its roads[12].S. Wang et al. [13] have worked on the distributed and partially autonomous decision based vehicular network to avoid the congestion among the urban areas. The proposed algorithm is known as “DIVERT” and it’s made capable of detecting & localizing the areas with heavy traffic which may lead to congestion, and computes the decongestion solution at earlier stage to avoid the congestion in the target area. Y. Zeng et al. [14] have worked on the vehicular fleet management, which also associated with the road event detection. This model relies upon the data collected through the vehicular sensors, which are also used to establish the opportunistic fleet, which is a localized vehicular mesh (or partial mesh). The event detection includes the several events such as stop, start, etc. to manage the movement of following vehicles in the group, and helps them to take the earliest action to avoid the vehicular hazards. M. Berlin et al. [15] have worked on the development of dynamic rerouting to avoid the various hazards & hurdles across the roads. The direction based hazard routing protocol (DHRP) model is developed with a distributed information network among the vehicles travelling in particular direction or destination. The various hurdles and hazards such as flash flood, tree falling, land sliding, accidents, etc. are detected as the events, and the appropriate action is taken for the vehicles, which can possibly be re-routed to avoid the prevailed situation. M. Sepulcre et al. [16] have focused on the Integration of congestion and awareness control in vehicular networks. The authors have proposed the congestion control method named as integration of congestion and awareness control (INTERN). This research works on channel busy ratio (CBR). The transmission parameters of every vehicle are adjusted in such a way, so that the load can be managed below the threshold CBR. It measures the transmission power of vehicle device so that it can calculate minimum power required for transmission of network packet. The authors have incorporated the proposed model to acquire dynamically adaptable to changing vehicular formation at every second, channel Load Awareness and the ability to maintain stable levels of channel load, which increases the application efficiency. The INTERN model hasn’t been tested with the highly dense traffic congestion and does not utilize the load balancing approach to minimize the traffic load over a single link. Also the existing model has been not found capable of the compression or optimization as it does not incorporate any message compression or optimization method. S. G. Manyam et al. [17] has been conducted their work in the VANET based upon the cloud environment. In order to improve traffic safety and provide computational services to road users, a new cloud computing model called VANET-Cloud applied to vehicular ad hoc networks is proposed. Various transportation services provided by VANET-Cloud are reviewed, and some future research directions are highlighted, including security and privacy, data aggregation, energy efficiency, interoperability, and resource management. Akhtar et al. [18] have proposed an algorithm in the presence of refuelling depots to route a vehicle. This paper aims at finding a route for the vehicle such that every target is met by the vehicle at least once, the fuel restriction is never breached along the vehicle path, and the total fuel needed by the vehicle is a minimum. It develops an approximation algorithm for the problem, and proposes heuristics for quick construction and improvement to solve the same. S. Bitam et al. [19] have proposed an algorithm with vehicle funneling constraint. This article focuses on saving the energy which is utilized on configuration of communication and other control systems. In order to achieve this single stream of data is sent from sensors to the destination. In order to reduce collision probability in wireless sensor networks, the same information is transmitted with lesser nodes and long packets. In order to get more benefits, the data compression techniques can be applied. R.S. Batth et.al [22] discussed about the available MAC protocols in TDMA based VANETS which are responsible for reliable communication in a temporary vehicular network for safety message dissemination among vehicles.

3. System Architecture

Vehicular ad-hoc networks make it possible for vehicles to communicate amongst themselves, thereby sharing important information like traffic congestions and accidents and ensuring timely response for the same. The traffic communication system consists of vehicles which include vehicles OBU (on board units), Vehicle to vehicle communication, vehicle to RSU communication and RSU to cloud communication. See Figure 1. The proposed model has been based upon the congestion detection and avoidance model, which is used to avoid the congestion conditions that occur due to any accident, road destruction, avalanche and traffic jams.

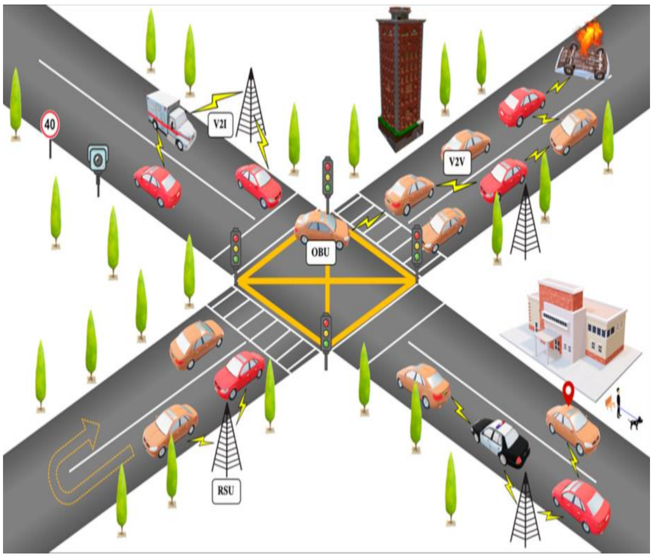

Figure 1. Traffic System [21]

In this system, if congestion based on VCI which is vehicle congestion index is found, then information is shared with other vehicles and RSU. Based on this congestion, a re-routing mechanism will check alternate routes available, based on remaining number of available roads. $R_{rem.}\{R_{id-1,} R_{id-2,} R_{id-3,} R_{id-3....} R_{id-n,}\}$.Then information is given to the other vehicles to re-route according to optimal path. The sequence diagram of the MRGM is described in figure 2. In this, traffic information is collected through vehicles and congestion is found through VCD (vehicle congestion density). The road weight calculation is done through PWC in order to find updated weights for finding the optimal path for vehicles.

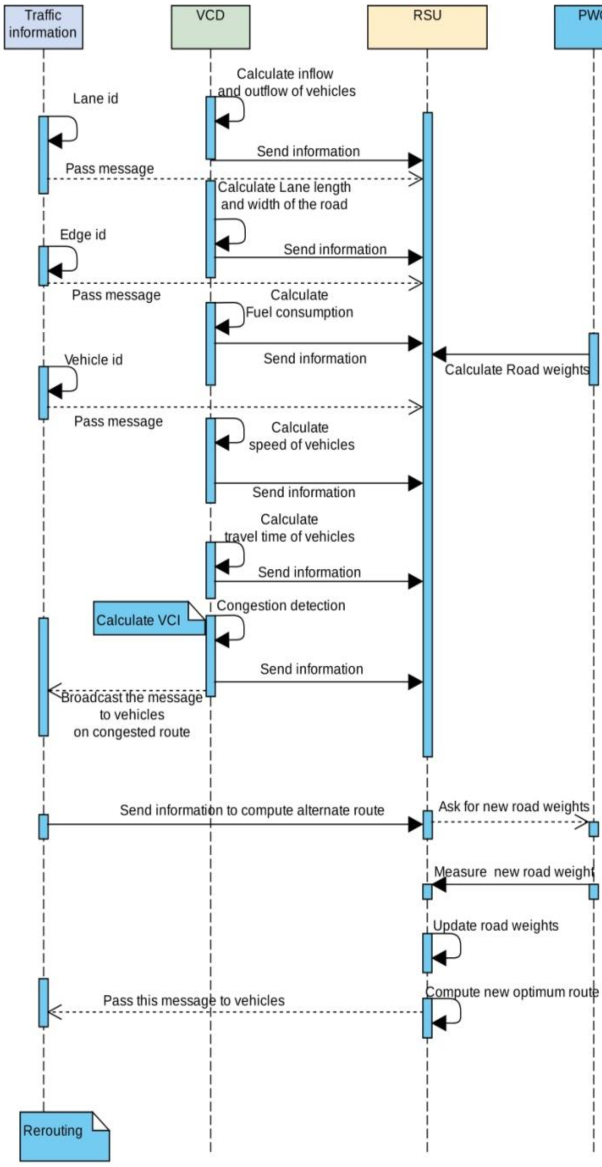

Figure 2. Sequence diagram of MRGM

4. Methodology

In methodology, MRGM mathematical equations and algorithms are explained. The methodology is defined with the various steps. In step 1: vehicle initialization is done which defines the various parameters required to define the vehicle like vehicle id, its departure position, lane id, road id etc. In step 2: collection of information of vehicle is done which includes the factors like vehicle average speed, emission data and fuel consumption. In step 3: traffic conditions are analyzed, based on road states and vehicles information in which road measurement like its width and length is analyzed, number of vehicles on roads and other traffic conditions. A function called vehicle congestion index will find the level of congestion like low congestion, moderate or high congestion. In step 4: traffic analysis is defined by which traffic congestion is predicted. In case congestion is found, then step 5 initiates the congestion control mechanism which provides the vehicle with information of finding the optimal route in case of congestion. There are various notions that have been used in explaining equations. It is defined in table 1.

Table 1. Notations

V_{id}: Vehicle id
V_{list}: Vehicle list
R_{id}: Road id
D_{Lane}: Departure lane of vehicle
D_S: Departure speed of vehicle
A_{Lane} :Arrival lane of vehicle
A_S: Arrival speed of vehicle
D_{Pos}: Departure position of vehicle
A_{Pos}:Arrival position of vehicle
AVG_t: Mean travel time of vehicle
F_C: Fuel consumption rate of vehicle
Q_t:engine fuel consumption per unit hour
U_t:Running speed of vehicle
E_V: Emission of gases
V_s:maximum vehicle speed it can achieved on road segment
V_A: Actual vehicle speed it has achieved on road segment
D_G: Gap between vehicles
L_R: Length of the segment of road
TT_P: Predicted time travel from source to destination of vehicle
TT_A:Actual time travel from source to destination of vehicle
W_R: Width of the road
W_V: Width of the vehicle
D_Y: Distance between vehicles
S_{TAZ}: Traffic assessment Zone
L_V: Length of the vehicle
n : Number of vehicles on road
AVG_S: Average speed of vehicle
$Traffic_F$: Total flow of traffic at particular time on highway
T_V: Width of vehicle
PWC: Path weight calculation
VCD: Vehicle congestion Density
RSU: Road side units

i) Vehicle Initialization: Each is vehicle is assigned with vehicle id (V_{id}) which is used to identify the location of the vehicle on the road. In this MRGM collects the information of vehicles which includes the current position of vehicle, its destination preferences, its longitude and latitude. The vehicle will travel along the predefined route initially. Vehicle attribute can be defined as vehicle information: $V_{id}|R_{id}|D_{Lane}|D_S|A_{lane}|A_S|D_{Pos}|A_{Pos}$. R_{id} defines the id of the road the vehicle shall drive along. D_{Lane}, D_{Pos} A_{lane} and A_{Pos} defines the lane on which vehicle is departed and arrived and position of its departure and arrival whereas D_S and A_S represents departure and arrival speed.

ii) Collection of Information related to Vehicles: While vehicles travel on the roads, the MRGM collects the operational information of from sensors deployed on vehicles, which includes average mean speed of vehicle (AVG_s), average mean travel time (AVG_t), Fuel consumption rate(F_C) and Vehicle gases emission Value (E_v) which includes CO_2, CO and NO_X values. The gases emitting from vehicles will help in determine current state of pollution level on particular segment of road.

iii) Traffic states determination: In order to analyze the congestion condition MRGM mechanism uses the multi-metric parameter system which includes various factors of inclusion like Width of road (W_R), Length of road(L_R), Width of vehicles(W_V), Length of vehicle(L_V). Based on above parameters, a report is generated which is defined as traffic flow report for n number for vehicles on particular road segment $Traffic_F$: n| AVG $_s$| AVG $_t$| F_c| E_v| W_R| L_R| W_V| L_V| is the concatenate of all values. After generating the traffic flow report the information is shared with all vehicles and road side units (RSU) on the particular road segment.

a) Traffic flow rate can be determined with average speed of vehicle on particular road segment which is calculated as

$$AVG_s = \frac{1}{n}\sum_{i=1}^{n} v_s \qquad (1)$$

Here n is number of vehicles and V_s is speed of each vehicle.

b) Vehicle density on particular road segment is calculated with two formulas

$$\sum_{i=1}^{n} W_v + D_G \qquad (2)$$

$$(\sum_{i=1}^{n} L_R) + D_Y \qquad (3)$$

Here D_G is the gap between the vehicles and D_Y is the distance between vehicles.

c) The traffic condition in MRGM is calculated in two ways:

- Bottleneck Condition: The condition that occurs when area(width) of road covered by multiple vehicles that wants to pass from road is defined as.

$$\propto = [\sum_{i=1}^{n} W_v + D_G]/W_R \qquad (4)$$

- Accidental or Jam Condition: The traffic condition that occurs due to any accident or any type of jam that can happen on road from last 300seconds is defined as

$$\emptyset = [\sum_{i=1}^{n} L_R + D_Y]/(L_V * n) \qquad (5)$$

Here $\propto$ and $\emptyset$ and two functions that define congestion condition based on width of road and length of the road$\propto$ and $\emptyset$.

d) Now the predicted time travel of vehicle on particular lane of road on a given segment is calculated as:

$$TT_P = (L_J^R)/V_{Vs}^J \qquad (6)$$

Here L_J^R defines length of road (R) with its road segment (J). V_{Vs}^J is speed of vehicle it can achieved on road segment J Total time travel from source to destination of vehicle which involves multiple roads is calculated as:

$$TT_t = \sum_{i=1}^{q} (\sum_{i=1}^{m} TT_P) \qquad (7)$$

Where q represents the remaining number of roads and m represents the segments divided on the road on which vehicles are passing.

Actual time of vehicle is TT_A which is calculated by using

$$TT_A = (L_J^R)/V_{Vk}^J \qquad (8)$$

Where V_{Vk}^J is speed of vehicle, it achieves actually during the travel

Now we define a function

$$\theta = \{\sum_{i=1}^{q} (\sum_{i=1}^{m} TT_A)\}/\sum_{i=1}^{q} (\sum_{i=1}^{m} TT_P)\} \qquad (9)$$

It calculates the predicted time requires for vehicle to travel and actual time it has taken to travel on a given route. Stopwatch is used to calculate the actual travel time

The fuel consumption on given road and particular segment can be calculated as:

$$F_C = \sum_{i=1}^{q} (\sum_{i=1}^{m} \frac{Q_t}{U_t}) \qquad (10)$$

Where FCR is fuel consumption rate, Q_t is engine fuel consumption per unit hour(kg/h) and U_t is running speed of vehicle in (Km/hr.).

iv) Traffic congestion analysis: In the MRGM, three parameters$\propto,\emptyset$ and θ are calculated for traffic states determination. Based on the following parameters, the following table is used to classify the vehicle classification index

Table 2. Vehicle congestion index

Vehicle Congestion Index(VCI)	Traffic state level
(0.0-0.3)	Free flow
(0.3-0.5)	Low congestion
(0.5-0.75)	Moderate congestion
(0.75-1.0)	High congestion

In MRGM, the cases are designed for traffic congestion analysis. The information collected is passed on to RSU nodes in order to analyze the traffic condition of an area which is called as (Traffic Assessment zones) TAZ.

Case1: The congestion occurs when width of the road is equal or less than the number of vehicles passing on the road section

$$S_{TAZ}\{\ \propto <= \textstyle\sum_i^n W_v + D_G]/W_R\ \} \qquad (11)$$

Case2: The congestion happens due to accident or traffic jams the length of road is occupied by the vehicles in particular lane.

$$S_{TAZ}\ \{\emptyset <= [\textstyle\sum_i^n L_R + D_Y]/(L_V * n)\ \} \qquad (12)$$

Case 3: If predicted travel time of vehicles is less than actual time travel on the route ,then this is the condition of congestion occurrence.

$$S_{TAZ}\ \{\theta <= \{\textstyle\sum_i^q (\sum_i^m TT_A)\}/\sum_i^q (\sum_i^m TT_P)\ \} \qquad (13)$$

The algorithm 1 to check vehicle flow density and congestion detection is explained below. In this various conditions are explained through which congestion can occur.

Algorithm 1: Algorithm for congestion detection

1: *Procedure for Congestion Detection*
2: *Collect the information of inflow and outflow of traffic data*
3: *Predicting the count of vehicle after every 300seconds.*
4: *Calculating the Average Length and Width of vehicles*
5: *Calculating the Width of Road*
6: *Calculating congestion condition 1*
7: *W_R less than or equal to $\sum_{i=1}^n W_v + D_G$*
8: *Calculating congestion condition 2*
9: *$(L_V)*n$ less than or equal to $(\sum_{i=1}^n L_R) + D_Y$*
10: *Calculate congestion condition 3*
11: *Travel time of vehicle Actual and predicted:*
12: *TT_A / TT_P*
13: *Measure Traffic assessment Zone S_{TAZ}*
14: *Calculate vehicle congestion density (VCD)*

v) Congestion Control: If congestion is detected based on conditions equations 11,12 and 13then congestion control mechanism is initiated. The RSU calculates the Traffic assessment zone(TAZ) of a area. After this K number of routes will be calculated. Each road constitutes edges and lanes. These are assigned with edge id and lane id. The weights are assigned to each segment of road. The RSU determine the shortest optimal path for vehicles. RSU will calculate the PWC (Path weight calculation) of road network. The PWC is calculated as

$$(PWC) = W_{ij}(\propto,\emptyset,\theta) \qquad (14)$$

It calculates the weight between edges of roads. If congestion is found then order to find alternate short route the equation is written below

$$W_{ij} = \min(W_{ij}, W_{ik} + W_{kj}) \qquad (15)$$

The algorithm 2 for congestion control is defined below a

Algorithm 2: Algorithm for congestion control

Procedure: Collect the information of flow of traffic
1: *Create graph of road network (R_{id1}, R_{id2}....R_{idn})*
2: *while SIMULATION do*
3: *if Simulation Time 600 s == 0 then*
4: *Pause Simulation*
5: *$S_{TAZ}(t)$ Traffic assessment zone(Graph)*
6: *Send message to $S_{TAZ}(t)$ to RSU to calculate PWC*
7: *For each road*
8: *Calculate VCD*
9: *If congestion found*
10: *Calculate new path*
11: *V_{list}*
12: *Shortest path (Subgrapgh)*
13: *$W_{ij} = \min(W_{ij}, W_{ik} + W_{kj})$*
14: *For all vehicles in vehicle in V_{List} do*
15: *$Current_{Pos}$ ← Current position of vehicle on road*
16: *$Last_{pos}$ ← Last position of vehicle on road*
17: *Shortest- Paths(subgraph,Current, last)*
18: *Message($Current_{Pos}$, $Last_{Pos}$)*
19: *New_{Path} ←Set new path*
20: *Message new path to vehicles on congested roads*
21: *End*

5. Simulation and Results

To simulate MRGM mechanism SUMO simulator is used which is an urban mobility traffic simulator with python script. In order to analyze the mechanism, open street maps of Downtown Los Angeles in USA, Melbourne region in Australia and Manhattan in USA are analyzed. The communication radius of RSU is 500 m. The simulation diagram for Los Angeles road map is shown in figure 3

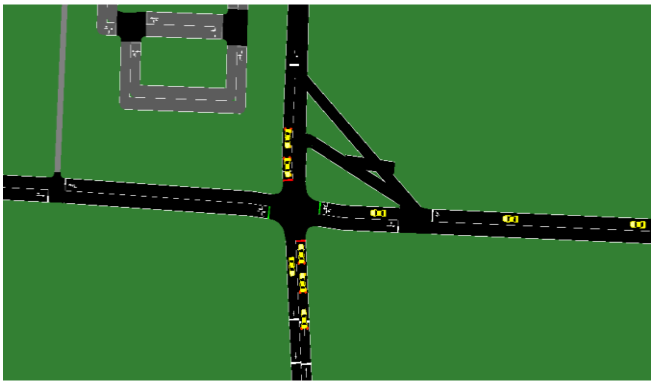

Figure 3. Simulation diagram

The various attributes of the vehicle used in sumo simulator is define below in table 3.

Table 3: Attributes of vehicles

Acceler-ation	Decele-ration	Min gap	Length of vehicle	Emission class	Max Speed
2.60ms^{-2}	4.50 ms^{-2}	2.50m	5m	HBEFA3/PC_G_EU4	55.31 Km/hr

The HBEFA3/PC_G_EU4 is a gasoline powered Euro norm 4 passenger car model for emission of pollution. The duration of simulation is 600s. Figure 4 defines the average travel time for vehicles in Melbourne, Los Angeles and Manhattan cities in minutes by using VCD

(Vehicle congestion density) function which varies from 0 to 1. As value of VCD increases, travel time also increases. It means when congestion increases, then average travel time also increases.

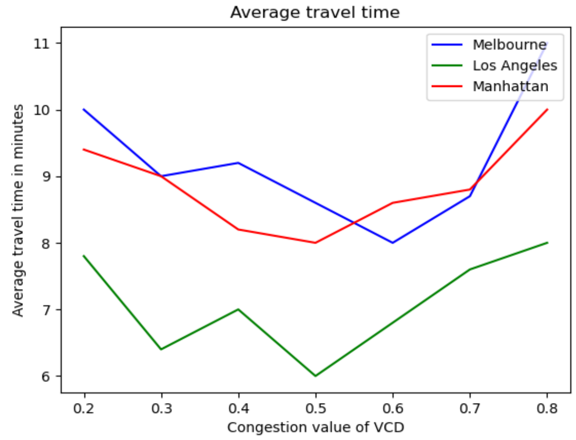

Figure 4. Average Travel time

In Figure 5 the effect of average speed of vehicle with VCD is defined. With increase in traffic density, the speed of vehicles decreases. In Figure 6 average CO_2 emission level is calculated. In figure 7 average fuel consumption of vehicles is measured with respect to VCD. The fuel consumption is calculated by speed of vehicles and length of road on which vehicles are running.

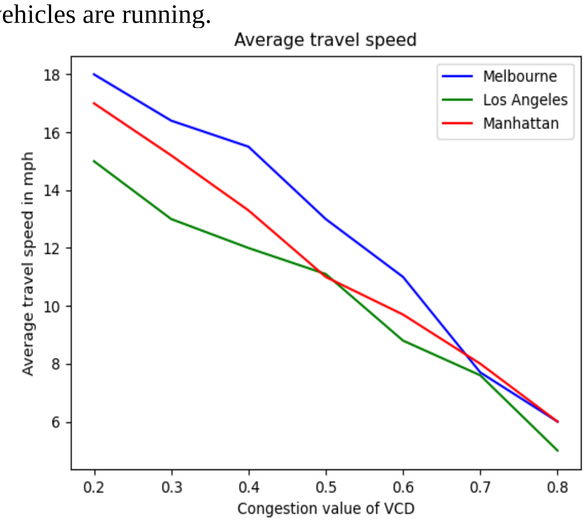

Figure 5. Average speed of vehicle

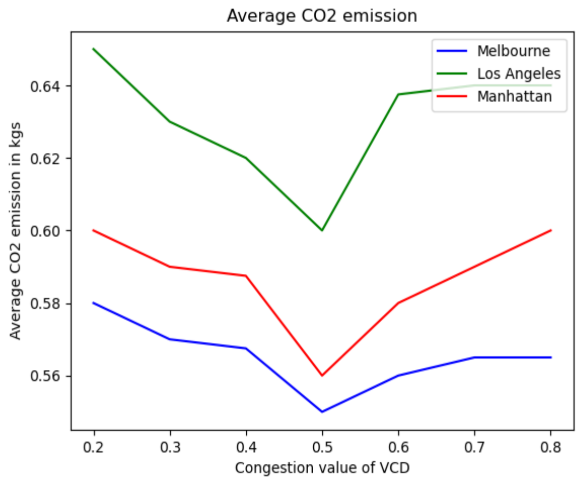

Figure 6. Average CO_2 emission

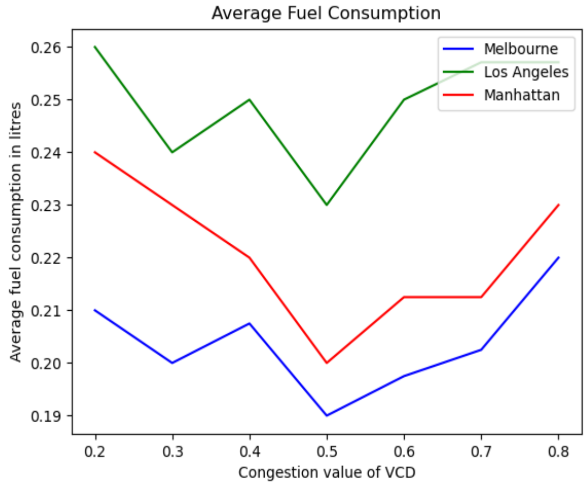

Figure 7. Average Fuel consumption

In Figure 8 the travel speed of vehicles is showed on Los Angeles map using MRGM. It has been found that when MRGM mechanism is used, then average speed of vehicles in urban area of Los Angeles is increased which reduces the travel time. Figure 9 shows the CO_2 emission on Los Angeles map. The CO_2 emission is less as there is less traffic jams and congestion occurs. Figure 10 shows the average fuel consumption by vehicles

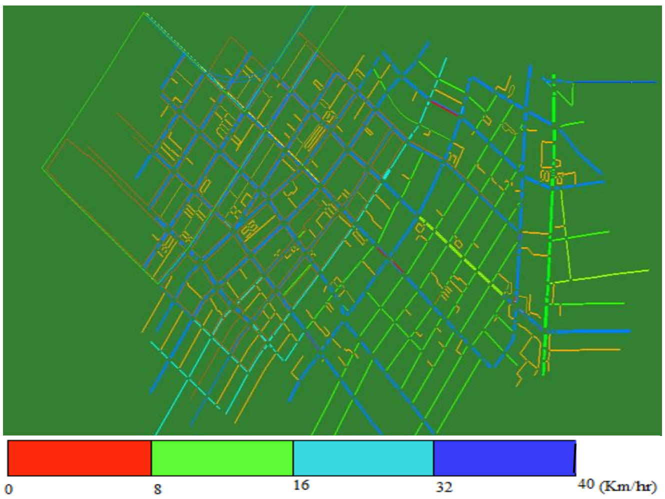

Figure 8. Average speed of vehicle on Los Angeles map

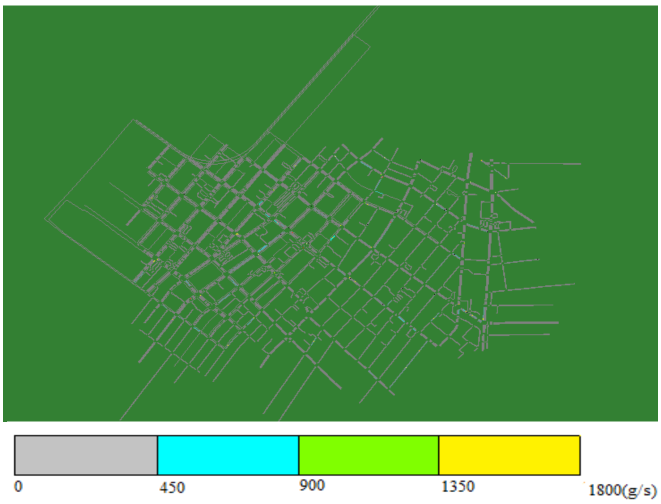

Figure 9. CO_2 Emission levels on Los Angeles map

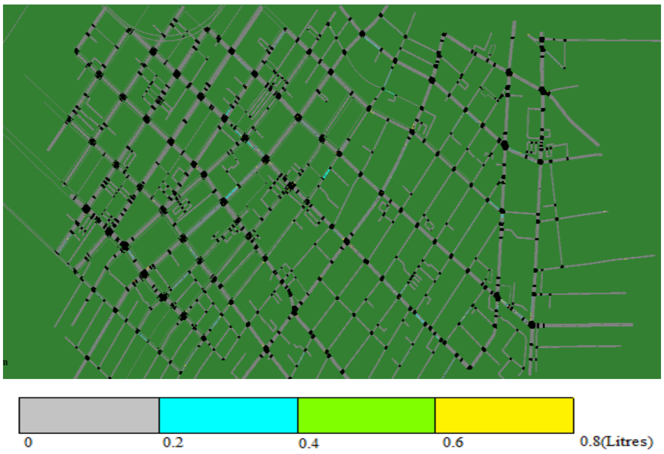

Figure 10. Average fuel consumption on Los Angeles map

The working of MRGM is compared with existing mechanisms like RTS, SSRGS and Refocus over three different urban areas. The comparison is done based on average fuel consumption, CO_2 emission levels and average travel time. The results show that MRGM has shown improved and promising results over these existing techniques and mechanisms. The Figure 11 shows that level of emission of CO_2 is reduced by using MRGM as compared to other mechanisms. The figure 12 shows the average fuel consumption which is reduced by using MRGM. The travel time for vehicles has also been reduced which is shown in figure 13. This is due to congestion detection and avoidance mechanism used by MRGM using the functions VCD and PWC for optimal route finding.

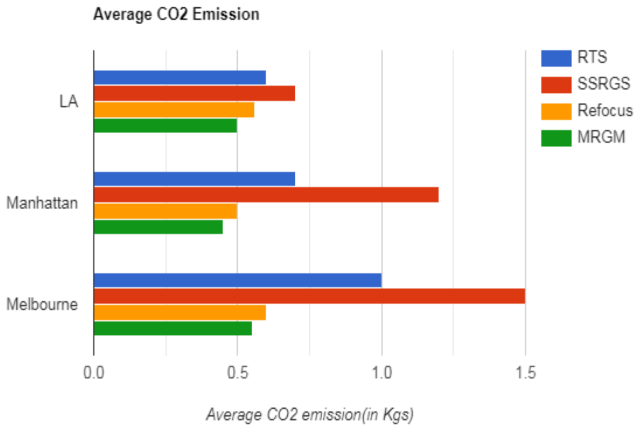

Figure 11. Average CO_2 emission

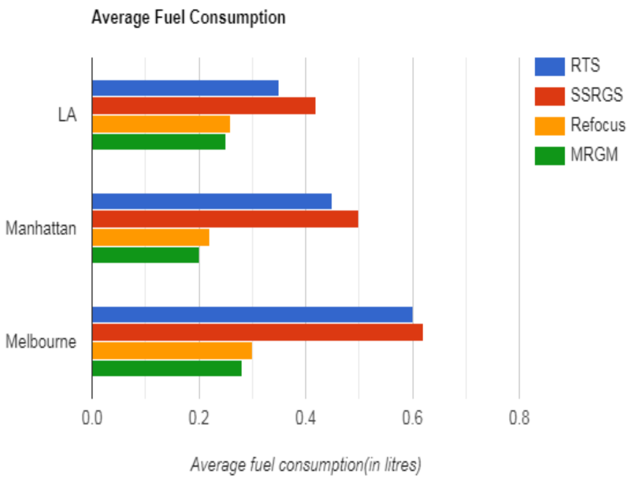

Figure 12. Average fuel consumption

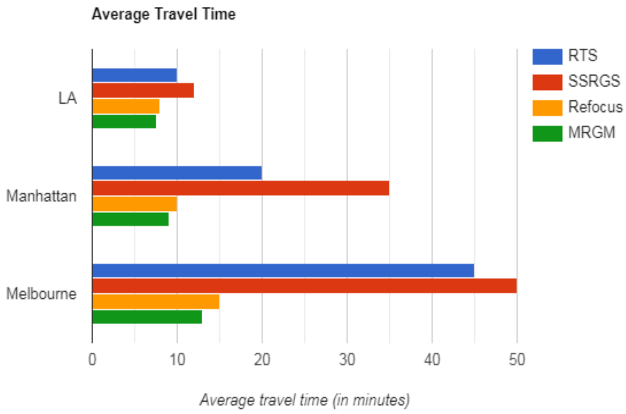

Figure 13. Average travel time

6. Conclusion

This paper proposed a mechanism named as MRGM which is multi-metric traffic congestion detection and avoidance mechanism for urban areas traffic conditions. Here a function (VCD) which is vehicle congestion density is used for measuring the traffic density based on which congestion conditions are defined. The PWC is path weight calculation which is used for understanding the conditions of roads, lanes and edges. With this mechanism, the average travel time on roads for vehicles has been reduced, fuel consumption is significantly lessened and CO_2 emission levels are also controlled. This mechanism detects the congestion and also provides rerouting for vehicles with optimal paths by setting new paths to vehicles. The Simulation results show that it has improvement over existing mechanisms in terms of vehicle fuel consumption, vehicle travel time and emission of gases.

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