RG Technique to Reduce the Fuel Consumption and Co_2 Emission in VANET

J. Prakash, N. Sengottaiyan, Anbukaruppusamy, K. Sudhakar, and R. Mahaveerakannan

Abstract In modern days, vehicular ad hoc network (VANET) was one of the rapidly escalating research areas. There were previously numerous ideas expected in this area, but the driving force in VANET was not completed yet. The various routing protocols and clustering algorithms used in VANET were not effectively concentrated on contamination drop in the environment. The day-to-day life demands additional vehicles with protection, but the greater part of us had not been accepted the reality to utilize additional vehicles with less contamination. In this paper, the ReGrouping (RG) technique is proposed, which condensed the fuel utilization of assorted vehicles in VANET. The CO2 emissions and traffic level in the scrupulous direction were reduced. VANET representation was urbanized using finite automata (FA). With the assistance of the FA model, the VANET is constructed. The proportional result between with RG technique and without RG technique was shown.

Keywords Finite automata · RG technique · Comparative result

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1 Introduction

The vehicular ad hoc network was created from the mobile ad hoc network [1]. The VANET uses various types of communication: they are vehicle to vehicle, vehicle to road side unit and vehicle to infrastructure. These communications need various types of sensor and technology [2]. The VANET uses wireless networking technology: they are wireless local area network (WLAN), Wi-Fi, Zigbee, LTE or cellular technology, and the latest one is visible light communication (VLC) [3]. The VANET is derived from mobile ad hoc network (MANET). The intelligent vehicular ad hoc network was a network where the vehicle data were stored and monitored [4]. It was an ad hoc network where there is no need of any extraordinary communications. It uses more sensors for monitoring the vehicle movement. There are various simulation software available in the industry, and the open source simulation (SUMO) is combined with a network simulator like net sim or network simulator 2 (NS2) to study the performance of VANET [5].

Figure 1 shows how a VANET was working. The sample VANET consists of only two vehicles that communicate between each other: vehicle to vehicle (V2V) [6]. The vehicles to infrastructure (V2I) will exchange data from vehicle to infrastructure. The road side unit (RSU) is used to gather the information from vehicles. The RSU used the Internet to transmit information from one RSU to another [7]. It was developed to reduce the traffic congestion and driver safety, to detect accident, etc. The speed governor was used to control the speed of the vehicle near speed breaker and accident zone and used where there is a pit in the road. This helps reduce the maintenance of the vehicle.

Vehicle communication takes place between V-V, V-RSU and V-I through dedicated short-range communication (DSRC) [8]. It works in 5.9 MHz bandwidth of 75 MHz and approximate range of 300 m. It is developed from intelligent transport system (ITS). The VANET uses two different types of models for effective communication. The first one is infrastructure environment, that is, permanent connection. The second is ad hoc environment, which is a movable environment. Based on these two models, only one VANET is developed [9]. The VANET consists of various

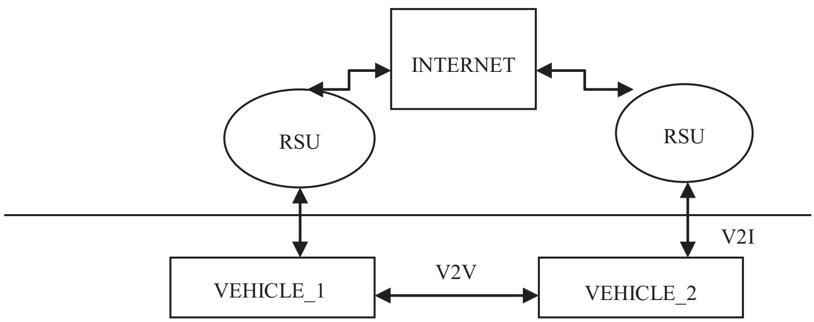

Fig. 1 Vehicular ad hoc network working model

characteristics, and the most promising characteristics were high mobility, rapid-changing network topology, predictable mobility, power criteria and time management. The VANET consists of various challenges yet to be solved. They are frequent location changes, congestion control and collision control, frequent signal changes and security.

Finite automata is a mathematical model which accepts the regular language (L). The proposed language L_v are L (language) and V (vehicle). The language L_v consists of a set of stings w_1, w_2,….$w_{n.}$. The designed finite automata will check whether the string is going to accept or not ($L_v = \{v^+\}L_v = \{v,vv,vvv,……\}$). The language L_v is developed for the VANET. It assists in developing FA model, and calculations were carried out for traffic reduction, fuel consumption and CO_2 emission.

In this work, ReGrouping (RG) technique is proposed which will condense the fuel utilization of assorted vehicles in VANET. The CO2 emissions and traffic level in the scrupulous direction were reduced. VANET representation was urbanized using finite automata (FA). From the FA model, the VANET is constructed.

2 Related Work

The VANET was advanced in order to avoid the latency associated with the data transmission. The 4G/5G network provides a high-speed Internet for data transfer. The vehicle can send their request and get their response from various locations. The heterogeneity of the VANET provides the wide range of connection.

[10] used the hybrid-fuzzy logic-guided genetic algorithm for the network optimization. The congestion control and the latency are associated with the data transmission in VANET, to improve the network performance. The most important part in the VANET was mobility prediction. For mobility prediction, hierarchical method is used to track the vehicle [11]. The available vehicle must be recorded for assigning the path from starting node to destination node. The vehicle's starting point is different when they meet at node P. We used clustering algorithms to group the vehicle from various nodes to node P. The inter-vehicle distance is calculated using the channel fading with frequencies and location where it is currently travelling [12]. The VANET is derived from the MANET; it contains high mobility of nodes. The network will automatically reconfigure. The topology used will change. The inference will vary while the nodes are moving. The media access protocol and clustering algorithm help reduce the inferences.

Various routing protocols are available for VANET. The routing protocols were responsible for the message transmission from one vehicle to another, as well as to infrastructure. The zone-based routing protocol will organize the vehicle that is travelling in same path. The various architectures of the zone-based routing were given a clear idea for construction of VANET. The moving zone-based routing algorithms organized the vehicle in scrupulous direction for better communication. The travelling object and indexed technique will show the number of moving vehicles in the network. The working of VANET depends on the traffic level in the city. The geographical source routing and the ant colony optimization algorithms find out the current level in the city. The multi-object resource optimization shows the optimized path selection for finding the best route.

The VANET communication must be much secured with the use of the digital signature and hash message authentication code [13]. The vehicle verification is very important in VANET. Registration process, information collection like various traffic levels ans new applications of vehicular sensor networks (VSNs) are used for communication. The dedicated short-range communication (DSRC) protocol has been designed [14]. The VANET uses various types of communication point vehicle to road side unit dissemination point (DP), relay and latency [15]. The future applications are going to rule the modern world [16]. Wireless message transmission will improve the traffic-level reduction in the city in a particular time. This is achieved by providing private security to the client of those who use the registered VANET [17]. Privacy preserving provides well-built privacy conservation to the vehicles, so that the adversaries cannot trace any vehicle [18].

The VANET is a dynamically changing and moving network. The node adjustment with security is one of the challenging tasks. Trust-extended authentication mechanism TEAM adopts the concept of transitive trust relationships to improve the routine of the confirmation process and only needs a few storage spaces [19]. The vehicular ad hoc network architecture provides various components that are present in the network [20]. Key hashed authentication protocol has improved the security level in VANET [21]. The group signature algorithms were used to develop VANET for bulk registration.

Vehicular cyber-physical systems is used to improve the system tracking. The clustering algorithm efficiency was measured in terms of metric [22], and this helps group the vehicle and RGP. Different-hop clustering scheme for VANETs generates cluster heads (CHs). These CHs operate and monitor the vehicle. They exchange data from one head to another and also to various components that are present in the VANET [23]. The tracking of vehicle is used to assign the students to the next vehicle. From the various studies, it's found that people were concentrated on improving the performance of the VANET. To reduce the latency associated with the data transmissions, they tried to improve the continuous connection in highly moving network and routing mechanism. The topology used in the network was enhanced. The various clustering algorithms are used to cluster the vehicle, to find the traffic congestion in a particular path. They had developed so many architectures in order to improve the working of fast-moving network. In all the above, they didn't concentrate on the reduction of CO_2 into the atmosphere from the vehicle. They didn't try to improve the environment and also to decrease the vehicle maintenance cost. The same concept can be applied in remote areas to reduce vehicles which in turn will reflect in the emission of CO_2 into the atmosphere.

3 Fuel Consumption in VANET Using ReGrouping Technique

ReGrouping (RG) technique is proposed which will condense the fuel utilization of assorted vehicles in VANET. The CO2 emissions and traffic level in the scrupulous direction were reduced. VANET representation was urbanized using finite automata (FA). From the FA model, the VANET is constructed.

3.1 Finite Automata

The FA idea leads to the construction of VANET for smart routing. The FA doesn't allow any other string that is not present in the language and will go accepting state. In the same manner, the VANET will work. The vehicle that is not registered in our network will not use our network. The vehicle, which is registered in our VANET, is allowed to reach the destination and utilize the benefits. As a result, security of the VANET network is improved. FA model is designed and it is given below. Figure 2 shows the finite automata model without ReGrouping (RG) technique.

For creating the VANET, identified the location and named it as K,H,S,A,V,E,K,P,U,I which was defined as set of states in FA(Q,$\sum$,q,q_f,δ) in which nodes(K,H,S,A,V,E,K,I) can act as starting node as well as accepting node. This VANET was in particular designed for Educational Institutions (EI). The each EI has so many vehicles in which all will take so many students to dissimilar position. The students those who were travelling in identical lane are chosen. Therefore, vehicles travelling in same path (K to I) were selected for designing the VANET. The vehicles should register in our network in order to utilize the benefits. The each Educational Institutions Vehicle (EIV) starts at various locations, were dropping the students in various locations. In the network at convinced end, number of students will be condensed by 50% and only some were reaching the destination node from

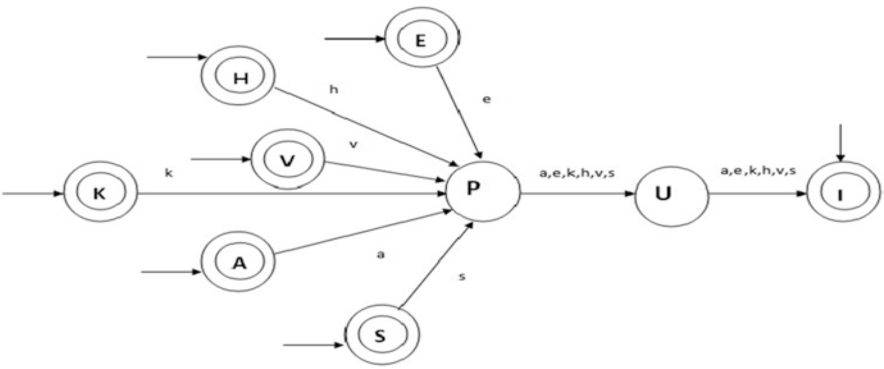

Fig. 2 Finite automata model without ReGrouping (RG) technique

each EIV. In the network, we found that the complete vehicles in a scrupulous lane were reaching the similar node in our VANET. We proposed a novel idea ReGrouping (RG) Technique here. ReGrouping is a way of altering the students from one bus to another. Using RG, students of various EIV were shifted from one EIV to another in order to reduce the number of EIV. The persons travelling towards same location was spotted in our VANET and also found that total strength is reduced by 50% in each EVI at ReGrouping Point (RGP). RGP in our VANET is node P.

Table 1 shows the transition table for the corresponding Fig. 2. The transition table contains the various states in which the finite automata were going to travel. The inputs given to the finite automata model were the various EIV. The input to the model starts from node K, V, A, S, H, and E reaches the node P. The node P is a common point in the network for all the EIV. From node P, the inputs will travel through the node U and it will reach the destination node I. In the transition Table 1, we had shown that functions had been worked at each node. The input given to each node and the respective operation are represented in the form of table. The various transition functions from each starting to destination node are derived. The transition function for various states (nodes in VANET) is given below

$$\delta\left(\mathbf{A,a}\right)=\mathbf{P},\delta\left(\mathbf{A,e}\right)=\phi,\delta\left(\mathbf{A,k}\right)=\phi,\delta\left(\mathbf{A,h}\right)=\phi,\delta\left(\mathbf{A,v}\right)=\phi,\delta\left(\mathbf{A,s}\right)=\phi$$

Form the node A, the starting point is A and each input is checked one by one. For A,a it moves to the node P. Then the rest of the input remained in the same state, therefore it is marked as ϕ.

$$\delta\left(\mathbf{E,a}\right)=\phi,\delta\left(\mathbf{E,e}\right)=\mathbf{P},\delta\left(\mathbf{E,k}\right)=\phi,\delta\left(\mathbf{E,h}\right)=\phi,\delta\left(\mathbf{E,v}\right)=\phi,\delta\left(\mathbf{E,s}\right)=\phi$$

Form the node E, the starting point is E and each input is checked one by one. For E,e it moves to the node P. Then the rest of the input remained in the same state, therefore it is marked as ϕ.

$$\delta\left(\mathbf{K,a}\right)=\phi,\delta\left(\mathbf{K,e}\right)=\phi,\delta\left(\mathbf{K,k}\right)=\mathbf{P},\delta\left(\mathbf{K,h}\right)=\phi,\delta\left(\mathbf{K,v}\right)=\phi,\delta\left(\mathbf{K,s}\right)=\phi$$

Table 1 Transition table

States/Input	A	E	k	h	v	s
→A	P	–	–	–	–	–
E	–	P	–	–	–	–
K	–	–	P	–	–	–
H	–	–	–	P	–	–
V	–	–	–	–	P	–
S	–	–	–	–	–	S
P	U	U	U	U	U	U
U	I	I	I	I	I	I
*I	–	–	–	–	–	–

Form the node K, the starting point is K and each input is checked one by one. For K,k it moves to the node P. Then the rest of the input remained in the same state, therefore it is marked as ϕ.

$$\delta(\mathbf{H},\mathbf{a}) = \phi, \delta(\mathbf{H},\mathbf{e}) = \phi, \delta(\mathbf{H},\mathbf{k}) = \phi, \delta(\mathbf{H},\mathbf{h}) = \mathbf{P}, \delta(\mathbf{H},\mathbf{v}) = \phi, \delta(\mathbf{H},\mathbf{s}) = \phi$$

Form the node H, the starting point is H and each input is checked one by one. For H,h it moves to the node P. Then the rest of the input remained in the same state, therefore it is marked as ϕ.

$$\delta(\mathbf{V},\mathbf{a}) = \phi, \delta(\mathbf{V},\mathbf{e}) = \phi, \delta(\mathbf{V},\mathbf{k}) = \phi, \delta(\mathbf{V},\mathbf{h}) = \phi, \delta(\mathbf{V},\mathbf{v}) = \mathbf{P}, \delta(\mathbf{V},\mathbf{s}) = \phi$$

Form the node V, the starting point is V and each input is checked one by one. For V,v it moves to the node P. Then the rest of the input remained in the same state, therefore it is marked as ϕ.

$$\delta(\mathbf{S},\mathbf{a}) = \phi, \delta(\mathbf{S},\mathbf{e}) = \phi, \delta(\mathbf{S},\mathbf{k}) = \phi, \delta(\mathbf{S},\mathbf{h}) = \phi, \delta(\mathbf{S},\mathbf{v}) = \phi, \delta(\mathbf{S},\mathbf{s}) = \mathbf{P}$$

Form the node V, the starting point is V and each input is checked one by one. For S,s it moves to the node P. Then the rest of the input remained in the same state therefore, it is marked as ϕ.

$$\delta(\mathbf{P},\mathbf{a}) = \mathbf{U}, \delta(\mathbf{P},\mathbf{e}) = \mathbf{U}, \delta(\mathbf{P},\mathbf{k}) = \mathbf{U}, \delta(\mathbf{P},\mathbf{h}) = \mathbf{U}, \delta(\mathbf{P},\mathbf{v}) = \mathbf{U}, \delta(\mathbf{P},\mathbf{s}) = \mathbf{U}$$

Form the node P, each input is checked one by one. For P,a,e,s,k,h,v it moves to the node U.

$$\delta(\mathbf{U},\mathbf{a}) = \mathbf{I}, \delta(\mathbf{U},\mathbf{e}) = \mathbf{I}, \delta(\mathbf{U},\mathbf{k}) = \mathbf{I}, \delta(\mathbf{U},\mathbf{h}) = \mathbf{I}, \delta(\mathbf{U},\mathbf{v}) = \mathbf{I}, \delta(\mathbf{U},\mathbf{s}) = \mathbf{I}$$

Form the node U, each input is checked one by one. For P,a,e,s,k,h,v it moves to the node I.

$$\delta(\mathbf{I},\mathbf{a}) = \phi, \delta(\mathbf{I},\mathbf{e}) = \phi, \delta(\mathbf{I},\mathbf{k}) = \phi, \delta(\mathbf{I},\mathbf{h}) = \phi, \delta(\mathbf{I},\mathbf{v}) = \phi, \delta(\mathbf{I},\mathbf{s}) = \phi$$

The node I is the destination node, therefore there is no more transitions. From the above transition functions, we are able to drive a common transition function

$$\delta(\text{states,input}) = \text{P union}\, \delta(\text{states,input}) = \text{U union}\, \delta(\text{states,input}) = I$$
$$\delta(X,w) = \text{P}\mathbf{U}\delta(X,w) = \text{U}\mathbf{U}\delta(X,w) = \text{I}$$
$$\sum \delta(X,w) = \mathbf{P}\,\mathbf{U}\,\delta(X,w) = \mathbf{I} \ldots\ldots \mathbf{1}\ \textbf{where}\ w = \{\mathbf{a},\mathbf{e},\mathbf{k},\mathbf{h},\mathbf{v},\mathbf{s}\}$$

- **D_EIV**→ Distance travelled by Educational Institution Vehicle
- **CO_2_EIV**→ **CO_2**(2640 grams per/liter) emitted by Educational Institution Vehicle

Table 2 Using equation the formulas derived

S.NO	Terms	Description	Formula
1	D	**D_EIV**	$\sum$ Di = 1 to n
2	C	**CO_2_EIV**	$\sum$ C i = 1 to n
3	M	**C_EIV**	$\sum$ M i = 1 to n
4	F	**F_EIV**	$\sum$ F i = 1 to n

Table 3 VANET without RG technique (per day)

NODE	EIV_K	EIV_H	EIV_S	EIV_V	EIV_A	EIV_E	Total
D_EIV	95	94	90	86.3	88	83	536.3
F_EIV	15.8	15.6	15	14.3	14.6	13.8	89.1
CO_2_EIV	41712	41184	39600	37752	38544	36432	235224
C_EIV	1106	1092	1050	1001	1022	966	6237

Table 4 VANET without RG technique (per week)

NODE	EIV_K	EIV_H	EIV_S	EIV_V	EIV_A	EIV_E	Total
D_EIV	950	940	900	863	880	830	3563
F_EIV	158	156	150	143	146	138	591
CO_2_EIV	417120	411840	396000	377520	385440	364320	1560240
C_EIV	11060	10920	10500	10010	10220	9660	41370

- **C_EIV**→ Cost spend on fuel by Educational Institution Vehicle
- **F_EIV**→ Fuel used by Educational Institution Vehicle

The designed VANET consist of various EIV. In our model, we made all the EIV to the start at various nodes and travel towards the same destination. In the below Table 2, we have calculated various EIV travel distances from their starting node to destination node. The Table 3 shows the fuel consumed, distance travelled by each EIV, CO_2 emitted by each EVI was calculated.

The below Table 4 shows the fuel consumed, distance travelled by each EIV, CO_2 emitted by each EIV is calculated and given below based on Table 3 for one-week travel while considering 5 days as working days.

3.2 RG Technique

RG Technique is a way of rearranging the students to assemble in reduced bus. ReGrouping technique helps to reduce the fuel consumed, distance travelled by each EIV, CO_2 emitted from each EIV. The finite automata after implementing RG technique have been designed and it is shown below. Figure 3 shows Finite automata model with RG technique.

The key idea in our VANET was to reduce the number of EIV by using ReGrouping technique at node RGP(P). In the above FA model, from RGP (P) the

Table 5 VANET with RG technique (per day)

NODE	EIV_K	EIV_H	EIV_S	EIV_V	EIV_A	EIV_E	Total
D_EIV	95	94	90	26.3	28	23	356.3
F_EIV	15.8	15.6	15	4.3	4.6	3.8	59.1
CO_2_EIV	41712	41184	39600	11352	12144	10032	156024
C_EIV	1106	1092	1050	301	322	266	4137

Table 6 VANET with RG technique (per week)

NODE	EIV_K	EIV_H	EIV_S	EIV_V	EIV_A	EIV_E	Total
D_EIV	950	940	900	263	280	230	5363
F_EIV	158	156	150	43	46	38	891
CO_2_EIV	417120	411840	396000	113520	121440	100320	2352240
C_EIV	11060	10920	10500	3010	3220	2660	62370

EIV travelling to the destination is reduced by half. As a result, the number of EIV was reduced by half. It will reflect in the fuel consumption, CO_2 emission and maintenance. From RGP (P), we reduced 3 EIV. The distance for each EIV, CO_2, fuel consumption is calculated for single way travel. The result is shown in Table 5.

$$\sum \delta\left(X, w1\right) = P \cup \delta\left(X, w2\right) = I \ldots\ldots \mathbf{2}$$

where $w1 = \{a,e,k,h,v,s\}$, $w2 = \{k,h,s\}$
S = Total no of students in each EIV

$$N = S/2$$
$$RG_v = \sum N \text{ where } i = 1 \text{ to } n$$

The number of EIV was reduced by half. Table 6 shows the Km travelled, fuel consumed, CO_2 emitted by each EIV for one-week trip considering 5 days as working days. Due to the reduction in EIV traffic from RGP to destination, we reduced little traffic during busy hours.

4 Results and Discussion

Experimentation is done using 64 -bit Ubuntu 12.04 operating system having Intel Core i7-2670QM processor @ 2.20 GHz and RAM of 8 GB. The network simulator tool used is NS2.34. The Table 7 shows the comparison of Km travelled, fuel consumed, cost for fuel, CO_2 emitted before and after RG techniques for one week (5 working days). The comparative graph is shown below.

Table 8 completely analyzes the distance comparison of each node before and after RG technique. It is clear from the results that D_EIV total after RG is 3563 and

Table 7 Overall Comparison per week

Overall Comparison per week			
NODE	Without RG Technique	With RG Technique	Difference
D_EIV	5363	3563	1800
F_EIV	891	591	300
CO_2_EIV	2352240	1560240	792000
C_EIV	62370	41370	21000

Table 8 Distance comparison

DISTANCE COMPARISON							
NODE	EIV_K	EIV_H	EIV_S	EIV_V	EIV_A	EIV_E	Total
D_EIV After RG Technique	950	940	900	263	280	230	3563
D_EIV Before RG Technique	950	940	900	863	880	830	5363

Table 9 Fuel consumption comparison

FUEL CONSUMPTION COMPARISON							
NODE	EIV_K	EIV_H	EIV_S	EIV_V	EIV_A	EIV_E	Total
F_EIV After RG Technique	158	156	150	43	46	38	591
F_EIV Before RG Technique	158	156	150	143	146	138	891

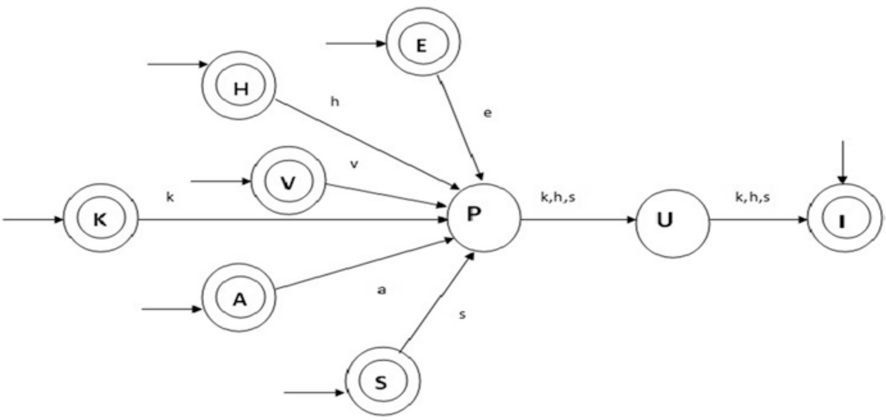

Fig. 3 Finite automata model with RG technique

before RG is 5363. Figure 4 confirms that distance covered after RG is very low than distance covered before RG. It confirms that with the usage of ReGrouping technique, there is no requirement for unnecessary distance travel, thereby reducing the fuel consumption, CO_2 emission and cost.

Table 9 gives the comparison of fuel consumption of each node before and after RG technique. It is understandable from the results that F_EIV total after RG is 591

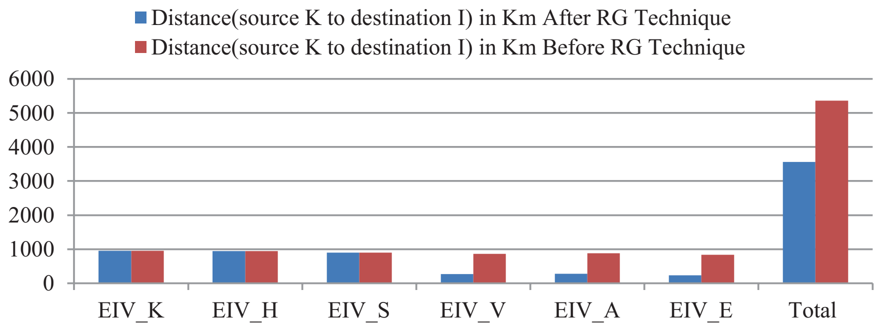

Fig. 4 Distance comparison

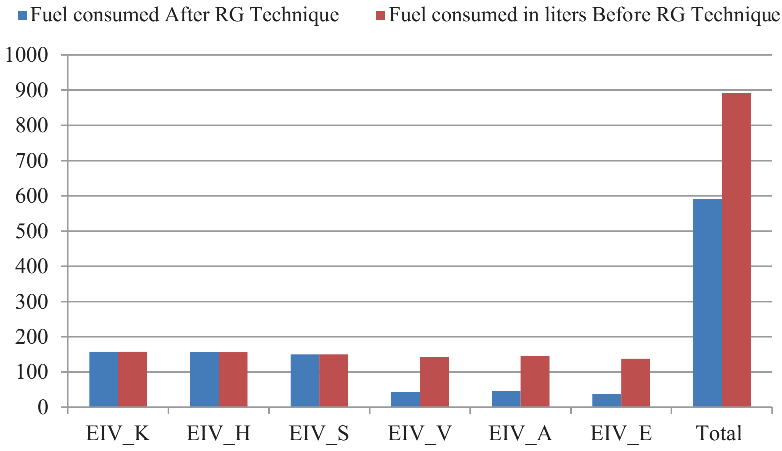

Fig. 5 Fuel consumption comparison

and before RG is 891. Figure 5 further points out that the fuel consumption before RG is extremely high than fuel consumption after RG. It reassures that with the assistance of ReGrouping technique, there is no necessity for needless fuel consumption, thereby reducing the CO_2 emission, distance travel and cost too.

Table 10 provides the comparison of CO_2 of each node before and after RG technique. It is obvious from the results that CO_2_EIV total after RG is 1560240 and before RG is 2352240. Figure 6 further assures that the CO_2 emission before RG is very lesser when comparing against the CO_2 emission after RG. It declares that with the practice of ReGrouping technique, the CO_2 emission is considerably reduced.

Table 11 gives the cost saving comparison of each node before and after RG technique. It is clear from the results that C_EIV total after RG is 41370 and before RG is 62370. Figure 7 confirms that the cost before RG is extremely high than cost after RG. It reassures that with the assistance of ReGrouping technique, there is no necessity for additional cost.

Table 10 CO2 (2640 grams per/liter) comparison

CO2(2640 grams per/liter) COMPARISON							
NODE	EIV_K	EIV_H	EIV_S	EIV_V	EIV_A	EIV_E	Total
CO_2_EIV After RG Technique	417120	411840	396000	113520	121440	100320	1560240
CO_2_EIV Before RG Technique	417120	411840	396000	377520	385440	364320	2352240

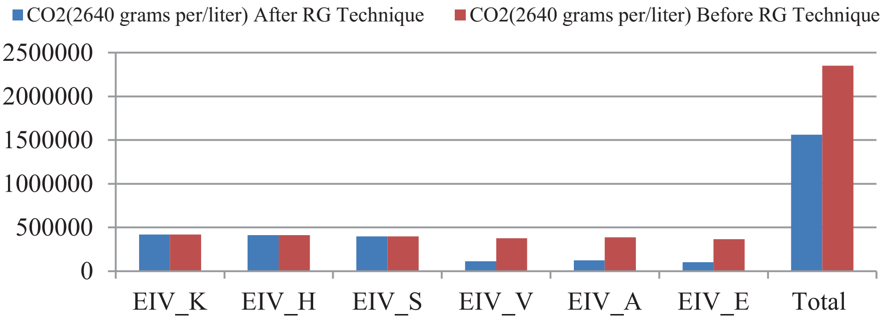

Fig. 6 CO2 (2640 grams per/liter) comparison

Table 11 Cost saving comparison

COST SAVING COMPARISON USING RG TECHNIQUE(in rupees)							
NODE	EIV_K	EIV_H	EIV_S	EIV_V	EIV_A	EIV_E	Total
C_EIV After RG Technique	11060	10920	10500	3010	3220	2660	41370
C_EIV Before RG Technique	11060	10920	10500	10010	10220	9660	62370

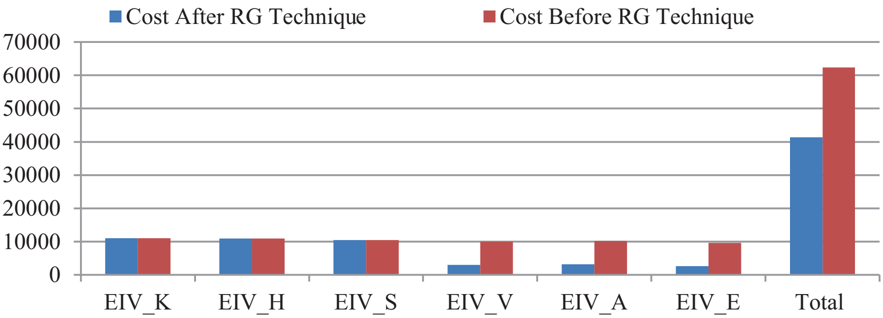

Fig. 7 Cost saving comparison using RG technique

5 Conclusion

In this research, we have surveyed various papers in order to learn how VANET is working. Here, we proposed a Finite automata model for designing our VANET. Using that model, we developed various formulas for calculating the fuel consumed by various vehicles, CO_2 emission from various vehicles, and the traffic reduction during peak hour. We also calculated the fuel, CO_2 and traffic level in weekly basis also. In future, the model can be combined with queuing technique for assigning the vehicle to reach the destination.

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