



SINR Based Energy Optimization Schemes for 5G Vehicular Sensor Networks

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Abstract

In Vehicular Sensor Networks (VSNs), the configuration of connected vehicles is in such a manner that enhances the data traffic. Due to this challenge, researchers have explored device to device (D2D) communication which provides the desired connectivity with mobility between the connected vehicles. It also reduces the energy consumption while increasing the system capacity. D2D communication is strongly affected by interference because it works with large number of vehicles in limited area. Various schemes have been attempted to manage interference while maintaining energy efficiency such as power control, mode selection etc. This paper presents a signal-to-interference-noise-ratio (SINR) based energy optimization technique for 5th generation VSNs. The major factors taken in account of are transmit power, battery lifetime, system load and SINR. An energy efficient algorithm is proposed with mathematical model to optimize the battery lifetime with respect to power control. Simulation results have been used to present the comparison of existing and proposed technique.

Keywords 5G · Vehicle to vehicle communication · D2D communication · Power control · Battery lifetime · Sensor networks · Energy efficient sensor network

1 Introduction

With the deployment of 5G networks in the year 2020 [1], new dimension of sensor networks for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) applications are being explored. Term coined for such networks is Internet of Vehicles (IoV) [2]. For improved network coverage and capacity, the cellular architecture of 5G network consists of pico and femto cells with ultra-high cell density. Such small sizes of cells result in frequent horizontal

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and vertical handover, especially in case of the nodes with high mobility. With the mobility support upto 500 km/hr in 5G, the nodes in IoV applications using cellular network undergo more frequent handover which may be horizontal or vertical. To overcome performance issues related to such handovers, micro and macro cells are also deployed which coexist and overlap with smaller cells, thus creating an umbrella cell structure. Early estimation of probability of such handovers can be utilized to establish connection with macro cells, thus reducing the number of fast handovers. This will also improve the energy efficiency and battery lifetime of the mobile node since each make and break of connection with the new cell head further increases the energy consumption. A different approach is D2D communication i.e. device to device which has been studied for smaller coverage area with congested traffic. It helps to reduce interference at certain level.

In this paper, we propose an energy optimization scheme for reliable and sustainable networks with high mobility devices. The proposed approach uses self-optimization algorithms for autonomous power control. Network QoS data, user application context and relative position of sensor nodes and access points is used to optimize the transmit power and mode of operation of network devices. A comparative analysis has been performed with the existing techniques to validate the improvement achieved by the proposed scheme in terms of the effect of transmit power on battery lifetime. Also the simulation results validate the mathematical modelling based upon signal to interference plus noise ratio.

For the presented work, the review analysis has been done for energy optimization in mobile sensor networks, especially in vehicular sensor network. The problem of average power consumption and energy efficiency are identified on the basis of review analysis. The major constraints taken into account for defining the algorithm as well as simulation are SINR, average power, system load and battery lifetime. The methodology and concept used in this paper to improve the energy efficiency and power consumption is better than the existing techniques which are explained with the help of graphical analysis in the simulation section.

The major contributions of the paper are as follows.

- Identifying the problem based upon rigorous literature review.
- The problem is defined as to optimize average power and energy consumption.
- A mathematical model is presented to analyze the problem, also an algorithm is given to resolve the issue of power consumption.
- The outcome of the paper is shown by simulation results that is optimized in terms of average power, SINR, system load and battery lifetime.

The paper is organized in seven sections. A brief of Vehicular Network with D2D communication is presented in Sect. 1. In Sect. 2nd some of the relevant literature has been discussed. The mathematical modelling with basic architecture of V2V & V2I in traffic congestion is designed in Sect. 3. Also an algorithm is represented for the self-organizing network with the comparative analysis in Sect. 4 and 5 simultaneously. The graphical analysis is shown in Sect. 6 followed by the discussion with future scope in Sect. 7.

2 Related Literature

Various techniques and approaches are used to optimize energy consumption of a wireless network within a limited area. One such approach is to establish device-to-device (D2D) communication link between the nodes. The D2D is preferred mode of network connectivity in many IoT applications since it requires nodes to operate at low power level due to small coverage distance with nearby nodes [1]. Further, the energy consumption at the Gateways or access points of cellular network is also reduced since they need not receive and send every bit of information exchanged between the nodes participating in the network [2]. Application of D2D in networks with mobile nodes such as sensors onboard moving vehicles or stationary sensors communicating with vehicles introduces additional challenges of mobile sensor networks. One of the major challenges faced by D2D networks used in IoV application is severe interference and multipath fading in the areas with traffic congestion and parking lots [3]. Such interference can be due to adjacent channels used by closely spaced vehicles or shared channels (co-channel) in nearby clusters [4]. Fading, if degenerative, will reduce the node coverage leading to link failure or demand for increase in the transmit power. Power control is a popular technique which not only reduces the effect of interference in D2D networks, but also increases the energy efficiency of the nodes since they operate at minimal power level required to maintain the link with neighbouring nodes [5, 6]. Another advantage of power control is to improve the performance in terms of fading channel quality of service (QoS) parameters such as signal to noise ratio (SNR), signal to interference noise ratio (SINR), throughput, data rate, bit error rate and outage probability. To instigate these benefits, intelligent data analysis functions are required at the sensor nodes, edge devices and core network. These functions must be adaptive and capable of processing data generated by network elements in real time to optimize network resources and processes.

Vehicular social networks (VSNs) have been studied due to the spontaneous increase in data traffic [7, 8]. VSNs combine the mobile and parked vehicles and there is an exchange of traffic data while communicating with nearby vehicles or infrastructure. To reduce the energy consumption while maintaining an efficient communication between the vehicles with minimum latency became the major motivation to test D2D communication in vehicular networks.

Since the transmitter and receiver end in D2D observe a point-to-point link, the latency is negligible compared to the network in which nodes are connected to a centralized control node or access point. D2D communication also reuses the wireless resources and enhances the capacity of the spectrum, with the limitation of being highly susceptible to interference.

To remove the adjacent and co-channel interference, channel extensions have been conducted which imply the use of wider bandwidths [9–11]. To solve interference problem, mode selection process is used [12–14]. Mode selection is a process in which different types of communication modes are selected like cellular mode, detection mode

and D2D mode. According to channel state, modes are selected to ensure the good quality of service and enhance the capacity of the system [15, 16]. Another approach to resolve the interference issues is based on power control method. It controls the interference by managing the power of device to device links [17]. It also enhances the efficiency of energy by reducing the transmission power in low interference situations and ensures good quality of service by increasing transmission power in high interference situation [18–20]. The energy and interference level of heterogeneous network has been optimized by using weighted function [21]. A dual decomposition approach is presented to encounter the problem of energy and interference in cognitive radio and heterogeneous network [22]. The power efficiency has been investigated for scarcity of spectrum in low power devices in 5G communication system [23].

3 Mathematical Modeling

In this section, traffic congestion scenario has been considered for the analysis of two D2D communication modes i.e. V2V (Vehicle to Vehicle) and V2I (Vehicle to Infrastructure). The parameters taken into account are SINR and received power. The traffic congestion scenario in an urban area is shown in Fig. 1.

Here, the ‘total number of vehicles’ set is represented by ‘V’. It consists of a D2D device set that is denoted by ‘D’. The number of mobile sensor nodes are considered to be ‘N’ which all are assumed to be active nodes. In reference to a particular node, (N-1) number of nodes generate the interference. For ‘N-1’ nodes the interference is $I_1, I_2, I_3, \dots, I_{(N-1)}$

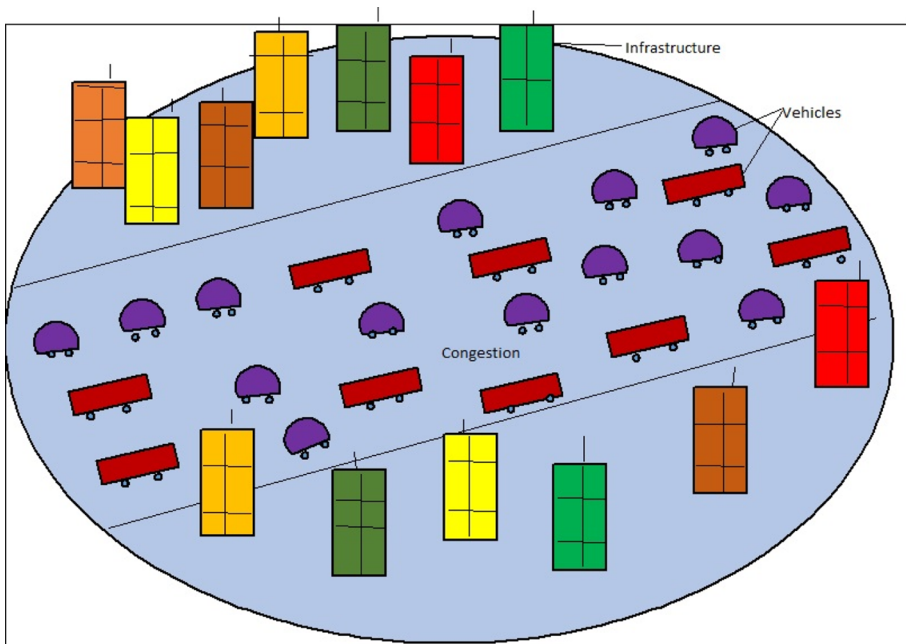


Fig. 1 Traffic congestion scenario

that sums upto ‘I’. The noise generated due to movement of vehicles, environmental factors and due to communication link is considered to be Gaussian noise ‘G_N’. The signal to interference plus noise ratio (SINR) of the reference node of the network can be calculated as

$$S = \frac{P_t}{I + G_N} \tag{1}$$

where $I = I_1 + I_2 + I_3, \dots + I_{(N-1)}$, or

$$\sum_{I=1}^{N-1} I$$

In Eq. 1, the SINR is represented by ‘S’, transmitted power of the reference node is P_t, the total interference created by (N–1) nodes is represented by ‘I’ and noise power spectral density is denoted by ‘G_N’ which is Gaussian in nature. The distance between devices with D2D communication or between the vehicles is in the range of 1 m to 50 m. The area taken for analysis represents region with high traffic congestion or the parking lot with large number of closely parked vehicles. In the case of Vehicle to Infrastructure, the distance between vehicles to infrastructure is taken slightly greater than vehicle to vehicle condition that is from 50 to 250 m.

Signal propagation has been considered to be dominated by free space communication and the interference generated by (N–1) nodes is presented in terms of received power of the surrounding nodes. Let us suppose, for ‘N’ number of mobile wireless sensor nodes, the power transmitted by surrounding nodes are P₁, P₂, P₃,.....P_(N-1) whose sums is equivalent to the total power created by the reference nodes i.e. equal to P_s.

The received power for free space communication can be written as [24]:

$$P_r = \frac{P_s \lambda^2}{(4\pi d)^2} \tag{2}$$

where $\lambda = \frac{c}{f}$ and

$$P_s = P_1 + P_2 + P_3 + \dots + P_{(N-1)}$$

Or

$$\sum_{P=1}^{N-1} P$$

In above equation, ‘P_r’ is received power of surrounding nodes, which is considered here to be equal to the interference generated by (N-1) nodes. Also the received power is equal to the transmitted power of the nodes. Here ‘P_s’ is total power of surrounding nodes, ‘d’ is the distance between the mobile nodes and ‘λ’ is represented in terms of speed of light and communication frequency of the nodes is in 5G spectrum. The value of ‘C’ and ‘f’ will remain fixed.

The scenario shows short term communication system. In the condition of congestion, the analysis is for Vehicle to Vehicle and Vehicle to Infrastructure communication. In both situations, we have to improve the SINR by reducing interference. To reduce interference, we have to optimize the transmitted power of the surrounding nodes which will reduce the interference and thus improve the SINR of the system.

In the proposed scheme, we identify the nodes with lesser loads from the pre-existing data saved in the control unit of base station. The controlling unit has all the details of load in a particular device at a particular instant of time. By utilizing this data base, it can be identified that which nodes are with lesser loads [24, 25] which implies that such notes are transferring little or no information. Enhancing the power of those nodes not increase the interference and thus improve the SINR of the whole system.

In second case, the nodes with low loads can be operated at lower transmit power level at a time which also improves the SINR due to reduced overall interference in the system and also improves the battery life of the mobile nodes.

So for SINR, replacing the value of ‘I’ with the value of ‘P_r’ in Eq. (1), we obtain

$$S = \frac{P_t}{I + G_N} \quad \& \quad P_r = \frac{P_s \lambda^2}{(4\pi d)^2}$$

$$\text{So, } S = \frac{P_t}{P_r + G_N} \tag{3}$$

$$S = \frac{P_t}{\frac{P_s \lambda^2}{(4\pi d)^2} + G_N} \tag{4}$$

$$S = \frac{P_t}{\frac{(P_1 + P_2 + P_3 + \dots + P_{N-1}) \lambda^2}{(4\pi d)^2} + G_N} \tag{5}$$

where $\lambda = \frac{c}{f}$ and

$$P_s = P_1 + P_2 + P_3 + \dots \dots \dots P_{(N-1)}$$

In above equations, the value of C is 3*10⁸ m/s, ‘d’ is the distance between the mobile nodes, ‘f’ will be the frequency taken in 5G scenario, P_t is the transmitted power and G_N is the Gaussian noise.

3.1 SINR Calculation in the Case of Vehicle to Vehicle

In this case the vehicles are at very densely packed traffic congestion situation. The distance between vehicles is merely at 1 m to maximum of 50 m, as it is the situation of high traffic.

There are ‘V’ number of vehicles with ‘N’ number of active mobile sensor nodes, let us suppose the interference created by ‘N’ number of nodes is ‘X’ so, the interference generated by ‘N-1’ number of nodes is X(N-1). The transmitted power of the reference node is taken as P_{tx}. The interference is represented in terms of received power i.e. P_{rx} and P_x sums to P_x=P₁+P₂+P₃+.....+P_{X(N-1)}.

The SINR ‘S’ is represented by below equation

$$S = \frac{P_{tx}}{X_{N-1} + G_N} \tag{6}$$

$$S = \frac{P_{tx}}{P_{rx} + G_N} \tag{7}$$

$$P_{rx} = \frac{P_x \lambda^2}{(4\pi d)^2} \tag{8}$$

So, Equation (6) becomes

$$S = \frac{P_{tx}}{\frac{(P_1+P_2+P_3+\dots+P_{X(N-1)})\lambda^2}{(4\pi d)^2} + G_N} \tag{9}$$

where $\lambda = \frac{c}{f}$ and.

$$P_{rx} = P_1 + P_2 + P_3 + \dots \dots \dots P_{X(N-1)}$$

The variation of received power from surrounding nodes is managed with reference to the interference caused by them along with optimizing the energy of the device battery at a certain level. Equation number 6 is obtained with reference to the above defined Eq. 3. It is the standard equation for SINR and received power. From Eq. 6 to equation number 9 the values have been incorporated as per node x.

3.2 SINR Calculation in the Case of Vehicle to Infrastructure

In case of vehicle to infrastructure the distance between vehicles and infrastructure is more as compare to vehicle to vehicle [26, 27]. For this case distance is taken from minimum 50 m to 250 m.

The scenario considered for analysis has ‘N’ number of active mobile sensor nodes for ‘V’ number of vehicles. Assuming that the interference created by ‘N-1’ number of nodes is ‘Y’ and the transmitted power with reference to a particular node is P_{ty}, the average power of all the different nodes are taken in consideration as the transmitted power may vary according to the vehicle-to-infrastructure distance. The SINR ‘S’ is presented by the equation given below:

$$S = \frac{P_{ty}}{Y_{N-1} + G_N} \tag{10}$$

$$S = \frac{P_{ty}}{P_{ry} + G_N} \tag{11}$$

$$P_{ry} = \frac{P_y \lambda^2}{(4\pi d)^2} \tag{12}$$

So, Equation (10) becomes

$$S = \frac{P_{ty}}{\frac{(P_1 + P_2 + P_3 + \dots + P_{y(N-1)}) \lambda^2}{(4\pi d)^2} + G_N} \tag{13}$$

where $\lambda = \frac{c}{f}$ and.

$$P_{ry} = P_1 + P_2 + P_3 + \dots + P_{y(N-1)}$$

Above equations has the similar presentation as given in Sect. 3.1. These equations are also deprived from the above defined equations for SINR and Received power (equation number 3).

4 Proposed Power Optimization Algorithm

The SINR based Vehicular Network Power Optimization (SVNPO) algorithm is proposed in reference to the scenario discussed in Sect. 3. The transmitted power of the surrounding nodes needs to be optimized while reducing the interference [28–30]. As we know that if the interference is reduced or the transmitted power of reference node is increased, in both the cases, the SINR of the network will improve. However, increasing the transmit power will reduce the device battery life time. Therefore, for ‘N’ number of mobile wireless sensor nodes in D2D mode vehicles, we have to optimize the transmitted power of the neighbouring nodes in reference with the centralize node of a self-organizing network [31, 32]. Since the communication is based on pico-cells, so it requires less transmitted power. In a congested area, when vehicle-to-vehicle or vehicle-to-infrastructure communication happens, we can reduce the power of surrounding nodes as compared to the reference node. We choose those surrounding nodes which have lesser load at a particular time so that there will be an efficient communication while reducing the interference. As there will be minimal or no information transfer within the system for low load nodes, they can be inactive at that time which reduces both interference and improves battery life of the mobiles nodes. Below is the proposed SINR based Vehicular Network Power Optimization (SVNPO) algorithm for both the constraints V2V and V2I.

Algorithm No. 1**SINR based Vehicular Network Power Optimization (SVNPO)**

Step 1

Initialize the parameters V, D, N, I, X, Y, G_N , S, P_s , and P_{tr} $G_N \rightarrow$ Fixed $P_{tr} = 23\text{dbm}$ S, $P_s \rightarrow 0$

Step 2

Define S

 $S = P_v/P_r + G_N$

/* Defined the SINR in terms of received power*/

Step 3

For V2V

Check S

 $S = P_{tr}/X(N-1) + G_N$

/* Calculate the SINR by using above formula for V2V condition*/

For V2I

Check S

 $S = P_{tr}/Y(N-1) + G_N$

/* Calculate the SINR by using above formula for V2I condition*/

Step 4

If S $\uparrow\uparrow$ Sel. (N-1) nodes \in Lesser Loads

/* Select the surrounding nodes with low load at a time*/

Go to Step 3

Step 5

If $P_{s(N-1)} \uparrow$ Then, I \downarrow Overall S \uparrow

/* Achieved SINR is in desired limit*/

Else

Sel. (N-1) nodes \in Lesser Loads $(N-1)_{LLD} \rightarrow$ Inactive

Then

 $P_s, I \rightarrow 0$ Battery Life \uparrow Overall S \uparrow

/* Inactive the surrounding nodes with no information transfer improves SINR and also saves battery life*/

Step 6

If S \rightarrow improved

Then Stop

Else

Recurring Step 1

S \rightarrow Desired Limit

/* If SINR is improved then stop the process otherwise repeat it till it reaches to desired limit of 'S' */

End If

End If

The algorithm defined above is for set of 'V' vehicles which has 'D' number of D2D mode vehicles in it. There are 'N' number of active mobile wireless sensor node and the interference generated by (N-1) is denoted as 'I'. The noise generated in environment is taken as Gaussian Noise ' G_N ', also the signal to interference plus noise ratio is calculated which is represented by 'S'. The interference caused by V2V and V2I is 'X' and 'Y' respectively. Also the transmitted power of the reference node is P_t while the transmitted power of surrounding nodes is P_s .

In step 1, initialization of parameters has been done, also the value of voltage drawn by battery and Gaussian Noise is fixed, transmitted power of reference node is 23dBm, the SINR and transmitted power of surrounding nodes is taken as zero at initial level.

In step 2, the general formula for calculating SINR is defined in terms of power and interference plus noise.

In step 3, the SINR 'S' is calculated for both the modes V2V and V2I.

The scenario which is taken into the consideration has a self-organizing network which has a reference node to transfer the information to base station so, if we enhance the transmitted power of the reference node, then SINR will also increase but at the same time interference also increases [33, 34]. This is the reason for which it has been propose to enhance the transmitted power of the surrounding nodes which has lesser loads so that current drawn from the battery is also managed while increasing the transmitted power. In this case interference will also be less as the communication is for shorter distance (i.e. congested area).

Also in second case the nodes which have lesser loads at a time can be inactivated so that there will be no requirement of increasing the power of surrounding nodes and battery life is also saved.

We check the SINR, if it is very high in reference with the desired limit then to optimize the SINR, some of the nodes with lesser load are selected and then again step 3 is repeated.

In step 5 the power of surrounding nodes with low loads is increased while the interference is reduced then the overall SINR of the system improves otherwise in other scenario the nodes with lesser load can be inactivated at that particular time. The deactivation of nodes improves SINR as there will be less information transfer and also it improves battery life.

The process will continue till it reaches upto the desired limit of SINR otherwise it can be stopped that is presented in step 6.

5 Result and Discussion

5.1 Simulation Performance

The parameters for simulative analysis are given in Table 1. The distance for vehicle-to-vehicle is taken in the range of 1 m to 50 m and vehicle-to-infrastructure is taken as 50 to 250 m. In simulation process the variation of SINR w.r.t. average power and system load has been observed. The frequency of signal is considered as 3.5 GHz and the network is assumed to be in 5G spectrum with Gaussian noise as 174dBm/Hz which is considered as environmental noise for free apace communication system [35].

Since the scenario considered for analysis is defined for traffic congestion, so the analysis is taken for shorter distance. If the distance exceeds more than the 50 m between the vehicles, then various additional parameters can be taken into account

Table 1 Simulation parameters for vehicular network environment

Sr. No.	Parameters name	Parameters values
1	Distance between Vehicle to Vehicle (V2V)	1 m to 50 m
2	Distance between Vehicle to Infrastructure (V2I)	50 m to 250 m
3	Gaussian Noise (G_N)	-174 dBm/Hz
4	Transmission Power of Node (P_t)	23dBm
5	Frequency of the Signal (f)	3.5 GHz

such as multipath fading, interference sources other than the network under consideration, frequent handovers, more power consumption, fast communication etc. The scope of this paper is limited to reduce interference level while optimizing energy in congested area so the scenario is defined upto 50 m.

We design a mobile network for vehicular environment and show that by varying different parameters, there is a vast improvement in SINR of the whole system. The network is analyzed using MATLAB 18A. The parameters defined above have been used for both mathematical analysis as well as in simulation process. Also an algorithm is defined above for reducing interference in system by utilizing the transmission power of the surrounding nodes with lesser loads.

The parameters chosen for simulation are according to the scenario consideration for the experiment. The situation is of Vehicular Sensor Network, in which mobile nodes are moving in a particular targeted area of 1 m to 50 m. As per the analysis, SINR has been optimized while balancing the load and energy level, so particular these parameters has been considered (Figs. 2, 3).

5.2 Simulation Results with Plots when Variation of SINR is w.r.t. Average Power

The Table number 2 presents the numerical values of parameters i.e. SINR and comparative values of average power for simulation results. The graphical representation of these numerical values is shown by the respective graphs in Fig. 4.

Here the graphs of simulation results are presented in which variation of traffic is shown different distances of D2D devices.

The commulative distribution function (CDFs) of transmit power is compared with SINR of the vehicular network for different distance threshold is shown in above simulation results. Figure 4a–d shows the improvement of SINR with respect to the transmit power of the signal. All the panels show that the proposed methodology is better than compare 1 and compare 2 [27, 28]. It is the basic property of CDF that the value varies from 0 to 1 [36–38] and it is well satisfied by the proposed simulation. In comparison to other techniques i.e. compare 1 [27] and compare 2 [28], proposed simulation results has better average transmitted power. Proposed technique has less power utilization with more SINR and other one has larger power consumption with more SINR. The proposed methodology increases the efficiency of the system while reducing the interference which improves overall SINR of the whole network.

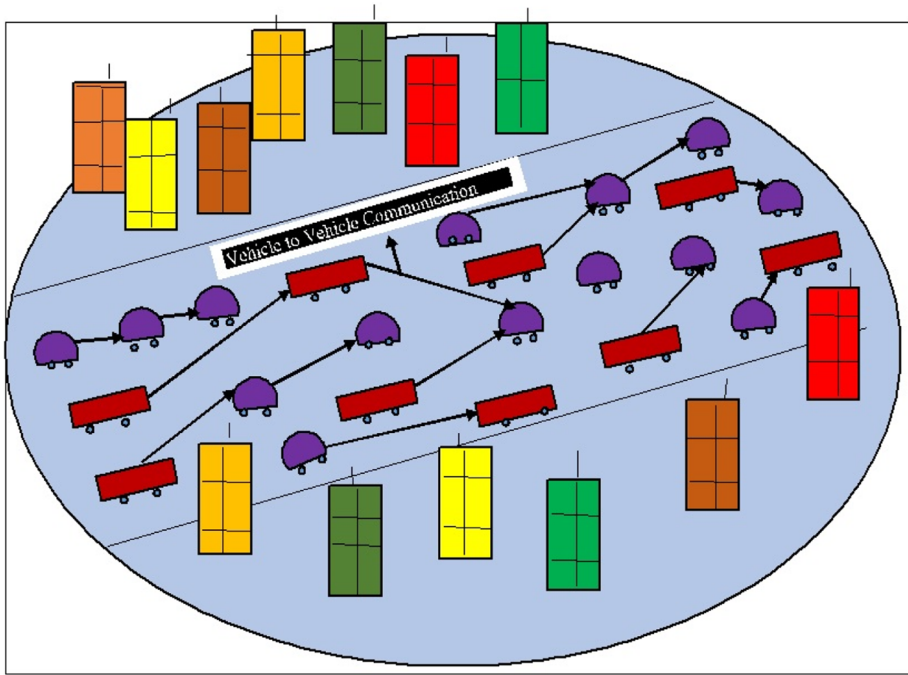


Fig. 2 Vehicle to vehicle communication in traffic congestion

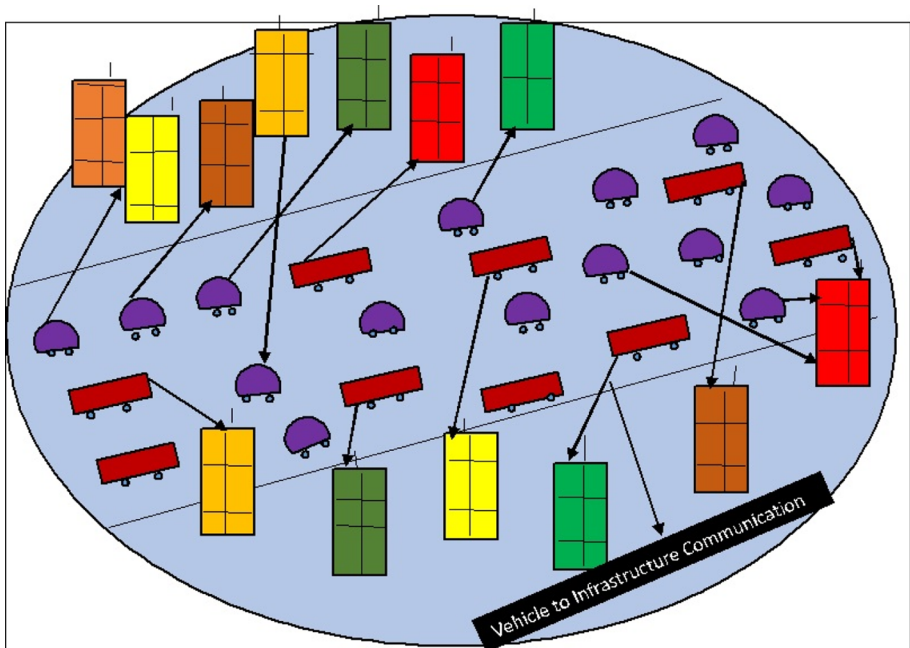


Fig. 3 Vehicle to infrastructure communication in traffic congestion

Table 2 Sample data for comparative values of SINR Vs. transmit power (a) when $d=50$ m with light traffic (b) when $d=250$ m with light traffic (c) when $d=50$ m with heavy traffic (d) when $d=250$ m with heavy traffic

SINR	Compare 1	Compare 2	Proposed	SINR	Compare 1	Compare 2	Proposed
a				b			
0	0.01	0.02	0.07	0	0.15	0.25	0.16
1	0.2	0.2	0.2	1	0.28	0.4	0.36
2	0.5	0.4	0.3	2	0.5	0.5	0.52
3	0.7	0.63	0.5	3	0.7	0.64	0.63
4	0.85	0.75	0.6	4	0.85	0.87	0.78
5	0.92	0.87	0.68	5	0.92	0.94	0.88
6	0.93	0.91	0.75	6	0.95	0.98	0.9
7	0.94	0.92	0.84	7	0.98	1	0.95
8	0.95	0.93	0.92	8	1	1	0.97
9	0.96	0.95	0.93	9	1	1	1
10	0.97	0.96	0.95	10	1	1	1
c				d			
0	0.1	0.03	0.05	0	0.03	0.03	0.015
1	0.3	0.3	0.2	1	0.2	0.2	0.18
2	0.5	0.4	0.4	2	0.45	0.48	0.3
3	0.7	0.6	0.65	3	0.7	0.6	0.52
4	0.9	0.7	0.8	4	0.9	0.74	0.67
5	0.94	0.87	0.88	5	0.98	0.88	0.8
6	0.98	0.93	0.93	6	0.98	0.98	0.85
7	1	0.98	0.95	7	1	0.98	0.92
8	1	0.98	0.98	8	1	1	0.98
9	1	1	1	9	1	1	0.98
10	1	1	1	10	1	1	1

5.3 Simulation Results with Plots when Variation of System Load is w.r.t. Average System Energy Efficiency

Table 3 presents the numerical value of Average Energy Efficiency of System w.r.t. System Load. The system load is in percentage and these numerical analysis shows that load is maintain while energy efficiency is increased.

As we have seen in the above section of algorithm also that while increasing the power of surrounding nodes with lesser loads, the interference of network reduces, hence the energy efficiency of the system increases. The proposed algorithm improves the system energy efficiency while maintaining the system load. The graphical representation of these values can be in seen in below figure number 5.

The graphical representation in Fig. 5 shows that energy efficiency of the system is continuously increasing though the system load decreases. As seen from the graphs that the proposed technique shows better results as compare to other technique i.e. compare 1 and compare 2 [27, 28]. The numerical analysis shows that in Fig. 5a proposed technique is 197 and 95 percent more than compare1 and compare2 respectively. The graphical analysis of 5b and c shows that proposed technique has 182 & 49 and 210 & 90 percent more

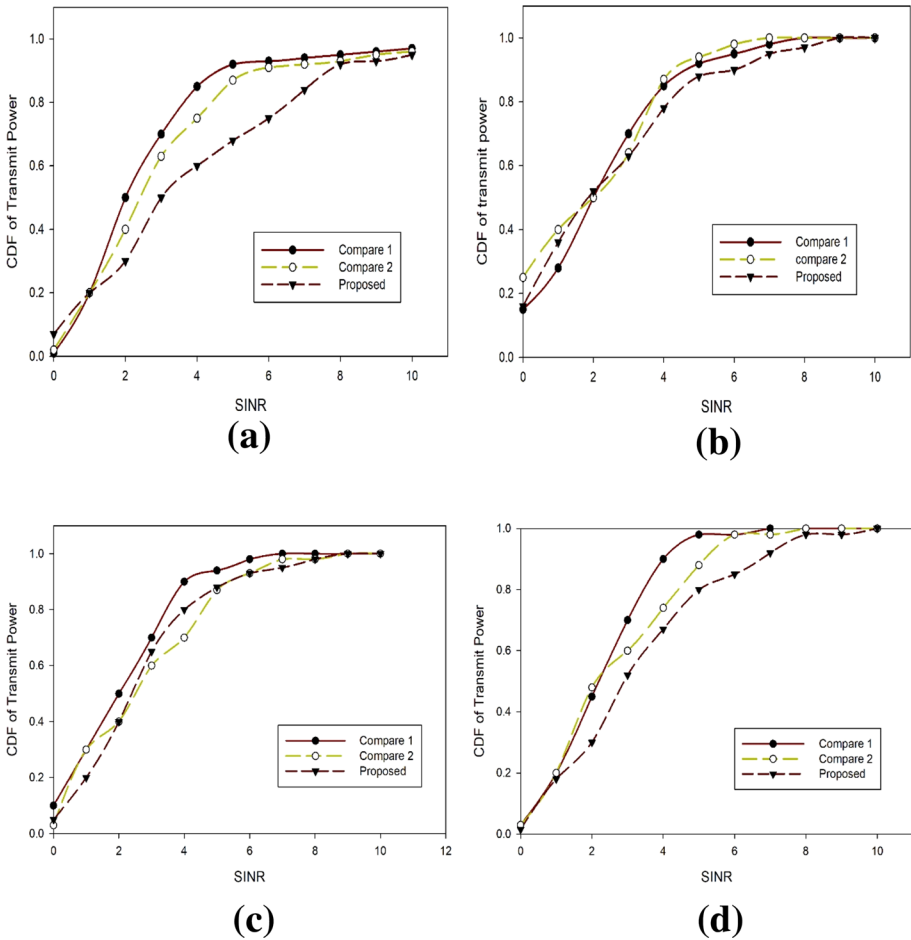


Fig. 4 Comparative analysis of signal to interference plus noise ratio with transmit power **a** when $d=50$ m with light traffic **b** when $d=250$ m with light traffic **c** when $d=50$ m with heavy traffic **d** when $d=250$ m with heavy traffic

efficiency than compare1 and compare2 respectively. Also in 5(d) it has been observed that the technique propose is having better efficiency as compare to compare1and compare2 i.e. 116 and 18 percent more. So, the proposed techniques serve better in energy efficiency as compare to other ones irrespective of light and heavy traffic.

5.4 Simulation Results with Plots when Variation of Average Transmit Power is w.r.t to 60 min Time Period

Table 4 has the numerical values for the simulation run for 60-min time period for analyzing the average transmit power and then compare it with the different techniques named as compare1 and compare2.

Table 3 Sample data for comparative values system energy efficiency vs. system load (a) when $d=50$ m with light traffic (b) when $d=250$ m with light traffic (c) when $d=50$ m with heavy traffic (d) when $d=250$ m with heavy traffic

System load (%)	Average system energy efficiency (Mbit/W)			System load (%)	Average system energy efficiency (Mbit/W)		
	Compare 1	Compare 2	Proposed		Compare 1	Compare 2	Proposed
a				b			
20	10.5	12	12.5	20	2.5	4.5	5.5
30	10	11.5	12	30	2	4	5
40	9.5	11	11.5	40	1.9	3.7	4
50	3.5	5.8	6	50	1	2.5	3
60	1	2.4	3.5	60	0.9	1.9	2
70	0.8	2.1	2.5	70	0.8	1.5	1.8
80	0.7	1.8	2.3	80	0.5	1.4	1.6
90	0.5	1.5	2	90	0.3	1	1.5
c				d			
20	3	4.3	5.8	20	0.9	2	2.5
30	2.3	4	5.3	30	0.8	1.9	2.1
40	2	3.8	5	40	0.7	1.8	2
50	1.3	2.6	4	50	0.65	1.7	1.9
60	1.1	2	3	60	0.62	1.5	1.7
70	0.9	1.6	1.9	70	0.55	1.48	1.52
80	0.6	1.5	1.7	80	0.5	1.38	1.43
90	0.3	1	1.4	90	0.4	1.2	1.3

The simulation based analysis of the above values is shown below in Fig. 6. Compare 1, compare 2 and proposed technique is shown in the figure which clearly state that proposed technique has better results as compare to other twos.

A simulation is run for 60 min to calculate the average of continuous transmit power. It has been observed that total average power remains almost same for the particular technique as the transmission of power is in very congested area due to traffic [39–41]. So, the overall average power remains same. As seen the above figure that all the three techniques have variation in same pattern with very little difference, so if the average is calculated that remains almost constant for the particular variable. It has also been seen with the bar graph given below.

Figure 7 shows the bar graph for compare1, compare 2 and proposed one which presents the average transmit power that is almost constant for a particular time period but it is clearly visible that proposed technique shows better performance as compare to other ones. It has an average value of 23.31 dBm while compare1 has 24.50 dBm and compare2 has 24.05dBm respectively which is larger than the propose one. That means if the transmit power is almost constant so there will be less interference and improved SINR of the overall system.

As compared with the existing technique like reinforcement learning methodology in vehicular sensor network, the proposed approach is far better in terms of SINR and average transmit power. It has also been observed from above simulations that energy is also

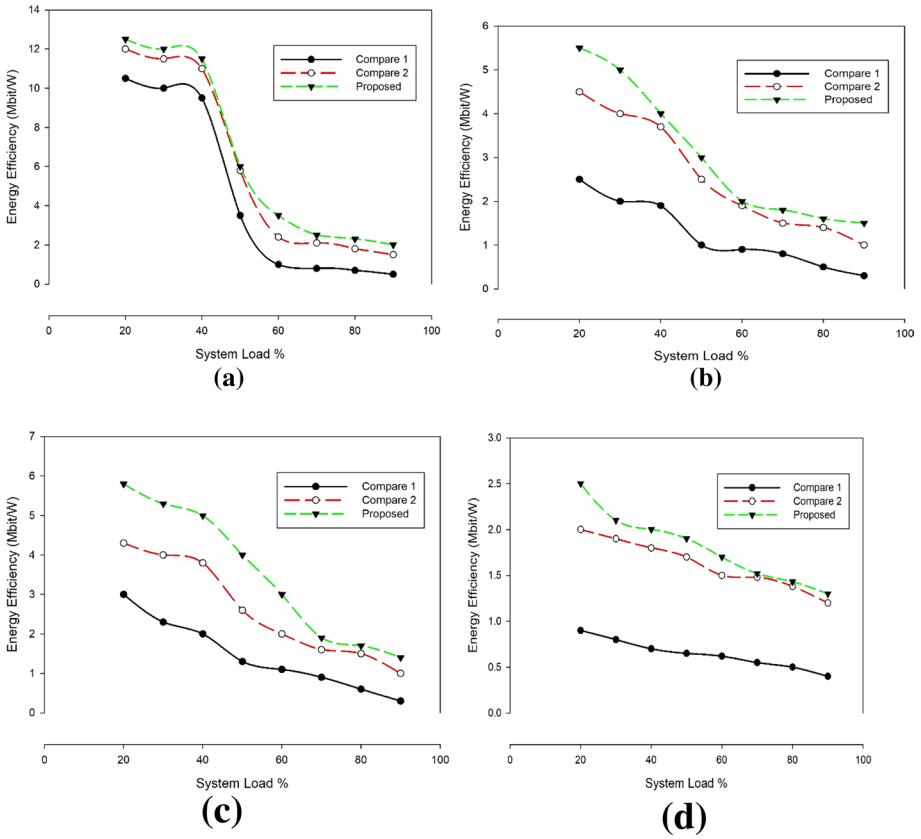


Fig. 5 Comparative analysis of system energy efficiency vs. system load **a** when $d=50$ m with light traffic **b** when $d=250$ m with light traffic **c** when $d=50$ m with heavy traffic **d** when $d=250$ m with heavy traffic

Table 4 Sample data for comparative values of average transmit power in 60 min

Time (min.)	Compare 1	Compare 2	Proposed
5	24.7	22.8	23.3
10	23.9	23.5	23
15	24.3	24.6	23.4
20	24.4	23.2	23.8
25	24.6	23.4	23.7
30	25.8	25.3	24.2
35	25.8	24.7	23.6
40	24.1	24.1	23.5
45	23.6	22.8	22
50	24	24.6	22.8
55	24.7	25.8	23.4
60	24.2	23.8	23.1

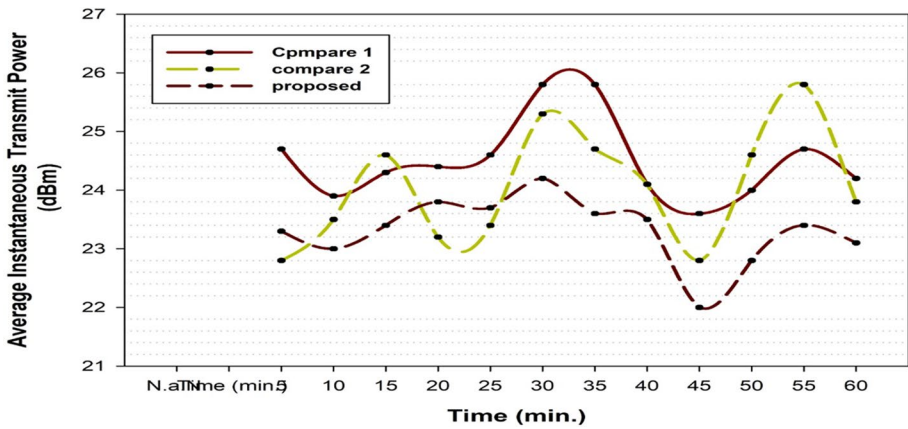


Fig. 6 Comparative analysis of average transmit power in fixed time period of 60 min

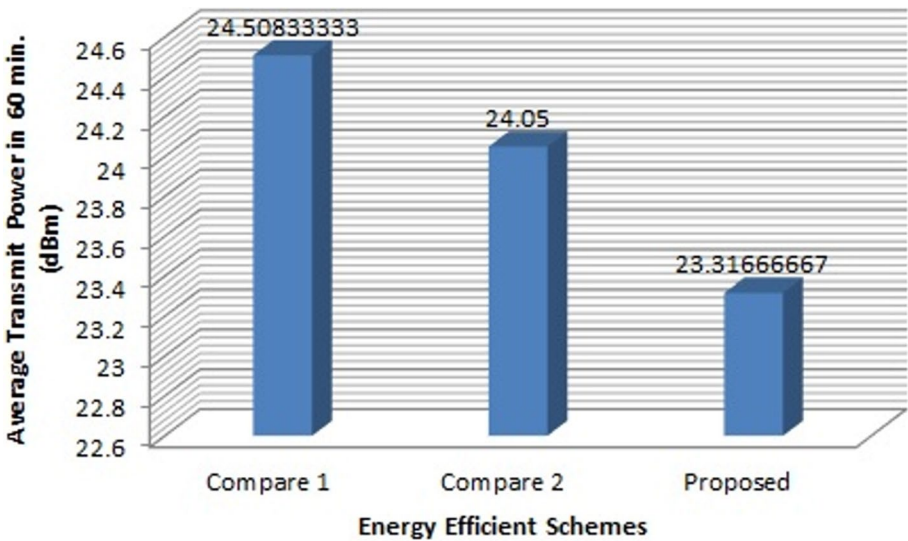


Fig. 7 Comparative bar graph analysis of average transmit power

optimized with proposed technique as compare to the existing one i.e. compare 1 [27] and compare 2 [28].

6 Conclusion

In a 5G vehicular sensor network environment, efficiency of V2V and V2I communication is critical to overall performance of the network. The interference in areas with density of vehicles, such as parking or road with traffic congestion, is very high and it uses lots of transmitted power to share the information in between while maintaining desired

level of SINR. The high node density increases interference and noise in the system which reduces the overall efficiency of the network. In this paper, an SINR based Vehicular Network Power Optimization (SVNPO) algorithm has been proposed to improve the overall SINR of the system without increasing the average transmission power of the network. It identifies the nodes with lesser load at surrounding and increase their transmit power to transfer the data. It enhances the overall system efficiency as compare to the system load. It balances the load as energy efficiency is increased while load is reduced. Simulation result show the variation in system load and SINR w.r.t. energy efficiency and transmit power respectively. It has been observed from the above results that proposed technique is better as compare to other two techniques named as compare1 and compare2. A separate analysis for average transmit power is done to show that average power remains almost same for a communication system within a congested area.

In future, we will consider the sharing methodology for nodes with D2D communication which uses the handover technique for making the real time environment energy efficient in a mobile network. Also the connectivity factor will be taken in account for better communication. The proposed work can also be extended with more realistic approach for wireless propagation schemes which shows the new challenges faced for different channel conditions and fading environment.

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