International Journal of Mathematical, Engineering and Management Sciences
Vol. 4, No. 1, 27–40, 2019
https://dx.doi.org/10.33889/IJMEMS.2019.4.1-003

Asset Distribution and Peerless Selection Approach for LTE based Multifarious VANET Networks

Arjun Arora*, **Nitin Rakesh**
Department of Computer Science and Engineering
Amity School of Engineering and Technology, Amity University, Noida, Uttar Pradesh, India
E-mail: nrakesh@amity.edu
**Corresponding author*: a.arora@ddn.upes.ac.in

K. K. Mishra
Department of Computer Science
Motilal Nehru National Institute of Technology, Allahahbad, Uttar Pradesh, India
E-mail: kkm@mnnit.ac.in

(Received July 26, 2018; Accepted October 18, 2018)

Abstract
Vehicular ad-hoc networks (VANET) over the past decade have been always part of research and enthusiasts, bringing in a lot of attention towards them. But with the tremendous swell in the imposition for mobile data VANETs are struggling to meet up. Vehicle to Vehicle (V2V) type of transmission is considered a very successful methodology for assuming trustworthy communication amongst vehicles participating in such communications. In the case of multifarious networks also considering the typical cellular network in which cellular links co-exist with V2V communication by making use of the same resources available in a given spectrum, resulting in a complex scenario. Therefore, it is a challenging issue to tackle with asset distribution and peerless selection. In this paper, a scheme is proposed which shows that peerless selection approach and asset distribution can be used as mixed user utility maximization with consideration of a joint network with the delay in transmission and reduction in power. To minimize the complicacy of computation a distributed algorithm is proposed which boils down towards a near-perfect solution by making use of the Lagrangian technique. The numerical analysis shows the extraordinary gains in throughput can be achieved specially with larger networks. The throughput of the network is also improved because of reduction in power.

Keywords- VANET, Networking, LTE.

1. Introduction

Over a few years, there has been observed a humungous increase in demand for mobile traffic as well as high speed access for data. As per the graphical network index is given by CISCO Systems (Al-Kubati et al., 2015), the total number of locomotive traffic globally is bound to grow ten times by 2019, approximately going upto 25 exa-bytes every month. Also, smart communication devices in totality are responsible for the generation of 97% of traffic data globally. Such huge amounts of demand for data lays a very substantial impact on conventional communication over cellular network owing to the limited resource spectrum specially for users at the edge of a cell or areas of the network where there is fading in such cases users are hardly able to enjoy connectivity. This makes it extremely important to find a solution to the problem of limited spectrum resource and need of a new architecture as well as selection of appropriate approach. With the advent of intelligent computing VANETs have attracted a lot of attention from researchers as well as government organizations (Al-Kubati et al., 2014; Alshaer, 2015). VANETs can be formed by making vehicles to communicate with vehicles (V2V) or making vehicles communicate with infrastructure (V2I) delivering information about vehicle status, position, emergency signal etc. (Arora et al., 2018). Even though VANETs are so much in demand the need of user cannot be fulfilled because of throughput and delay. Communication among devices often termed as Device to Device (D2D) communication enables direct transmission amongst physically near-by users by making use of similar resources as used by regular users of a cellular network. This method is considered to be promising and reliable in providing connectivity (Balasubramanian et al., 2008; Bai et al., 2015; Bazzi et al., 2016). With the introduction of Device to Device communication there arises an event for V2V support with the strict quality of service standards. The working of D2D is replicated in V2V by making use of the same spectrum resources as in the case of cellular networks (Bazzi et al., 2016). The benefits of V2V style communication is not only limited to enhancing the structural capability but also it can help improve on energy efficiency, fairness and delay in a given network. Some prominent related research work has been done on LTE-VANET multifarious networks over the past decade. Researchers analysed the impact of floating car data in comparison to human -2-human traffic in case of a cellular VANET multifarious network and make the design of a simple floating car data scheme which is then evaluated with the input of human-2-human traffic. In (Bessani et al., 2013; Bitam and Mellouk, 2014) the influence of combining spectrum bandwidth is assessed in the case of multifarious networks. Researchers investigated varied graph colouring schemas for asset sharing in order to solve multiple joint blocks of resources (Elazab et al., 2017) and transmission of power allocation issues. Researchers have shown geographical based re-use of cellular user schemes which aims at increasing the total sum rate, at the same time decreasing the rate of achievement (Di Felice et al., 2012). In the paper of George and Venugopal (2012) a location based asset distribution scheme for D2D communication which can be implemented in V2V environment is developed. An algorithm for asset distribution is used in order to reduce cellular resource consumption (Han et al., 2010). In paper of Jemma et al. (2015) researchers have developed a joint asset distribution and power limit algorithm in order to increase the total rate of the sum for cellular users which generates latency as well as the reliability of vehicles. Khaitiyakun et al. (2014) developed a framework over mobile users association and mode of transmission which switches between direct and D2D for improvement of spectrum and energy efficiency. Malandrino et al. (2012) researchers have proposed election mechanism for the nomination of a cluster head which is used effectively manage all the sub-clusters formed within a given VANET. This ultimately guarantees communication of multimedia content over a partially distant group of vehicles. A cloud based distribution scheme is studied so that safety messages can be sent over the cloud server to the suitable mobile gateway and related messages be distributed within the vehicles in the vicinity in-case of V2V (Mershad and Artail, 2013). In paper (Mershad et al., 2012a) authors have debated on an algorithm on fuzzy logic, which has gateway draft from a given VANET to an advanced LTE infrastructure providing more safety and security in transportation, quality services and associated applications. Data offloading for traffic from LTE to VANET is assessed and formulated simply as maximum flow problem for optimization (Mershad et al., 2012b). In work of Mostafa et al. (2011), researchers have deployed an LTE-VANET multifarious network in order to achieve an efficient distribution of data, using which the game theory concept is combined and applied in order to provide the simulation of vehicles for joining condition and maximizing an efficient rate of data in transfer. With huge V2V communication links it results in a more complex interference scenario. The cellular user suffers interference generated from V2V communication and base stations (B_S), severely disturbs the signals received and their quality owing to re-use of the spectrum. The scenario gets worse due to high fluctuation in V2V services causing in-efficient utilization of resources. The occurrence of idle $\mathrm{B_S}$ and vehicular transmissions (V_T) results in wastage of power with over interference ultimately resulting in deterioration of performance in a given network. Turning off idle B_S and V_T

benefits in saving power as well as helps in avoiding interference. Using this observation as the basis this paper makes an attempt to explore the perfect peerless selection scheme and asset distribution in order to provide improved capacity. The proposed schema can be deployed in various situations especially in case of emergency, providing high quality and application service for users of vehicles. The highlights of this paper are briefed in the following mentioned points:

a. This paper proposes a peerless selection approach and asset distribution scheme in LTE-VANET multifarious network. In such a network vehicular users take decisions for selection of an appropriate scheme and capture corresponding resources between LTE-communication and device to device based vehicle to vehicle communication. Cellular users in such a case need to choose their own peerless suited B_S. Maximization of the utility problem is made by combining all the users in joint consideration with topology, delay in transmission in V2V and minimization of power. This serves as a standard using which other scenarios can be assessed having a much more complicated network.
b. In order to avoid computation complexity of higher magnitude for large scale networks, an algorithm is devised which only takes two steps i.e. double decomposition is taken into consideration to find solution to maximum utility problem taking into account all B_S and all the vehicle transmissions are made to work in active mode with all the idle B_S and V_T being switched off, this results in higher throughput performance because of interference minimization.
c. Numerous numerical situations are conducted in order to assess the proposed algorithm under varied conditions of traffic. Results of various simulations show that a huge change in throughput can be gained by making use of the algorithm proposed especially with the increase in the network. It may be noted that simulations also show that throughput can also be improved re-mark ably by exploiting reduction power.

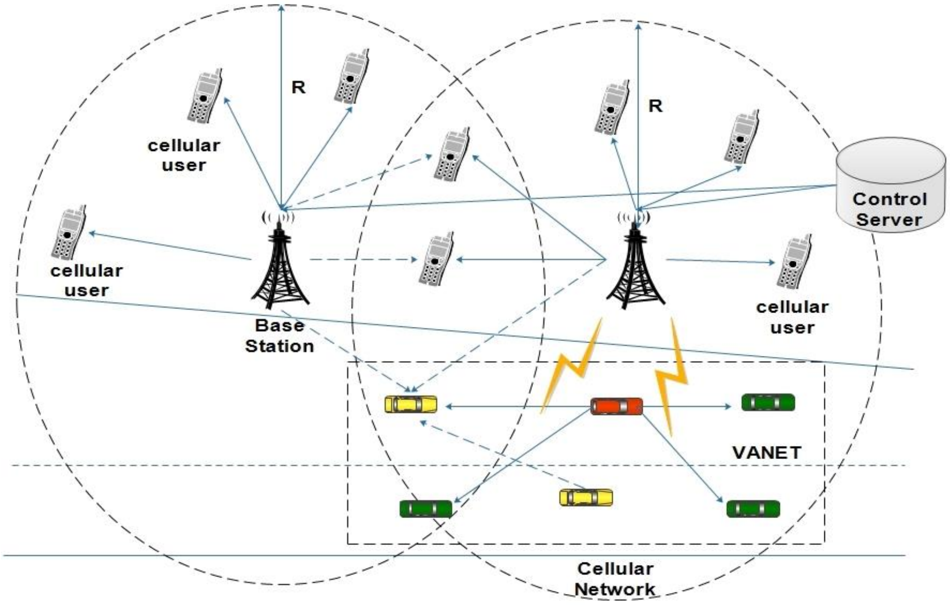

Figure 1. Graphical model for cellular- VANET with divergent network

2. Network Model and Formulation of Problem

In this section, the network model is discussed along-with network topology, interference, delay in transmission and problem formulation is made. This paper mainly targets on the down-link aspect. Now if we scrutinize an LTE-VANET multifarious network, which includes typical communication links as in a cellular network with a given collection of Device to Device (D2D) based V2V as shown in Figure 1. The B_S simply gets hold of the central part of a given macro-cell having radius (r) and cellular users are haphazardly scattered in the given cell. Through this cell a road crosses and all the vehicles which are receiving and are equipped with user equipment can communicate amongst the vehicles in the neighbourhood and at the same time contain cellular interface in order to deploy an explicit communication with the cellular network. A majority of vehicles having both the types i.e. transmitting ones as well as receiving ones move towards the cell-block which is completely covered and has density of $'\rho'$ vehicles/meter. Taking into consideration $'\gamma T_{NV}'$, as vehicles transmitting (V_T) are uniformly scattered on the straight road which includes selected V_T and candidate V_T and where γ is the ratio of number of V_T and total numbethe r of vehicles (T_{NV}) on the given road. When each of the vehicular receivers(V_R) communicate with its own V_T then unselected V_T are considered as candidate V_T. Due to time dependent different conditions of traffic a given candidate V_T will turn into serving V_T simply in order to provide wireless communication to surrounding V_R. There are two types of links which co-exist in case of cellular communication one between B_S and cellular user and the other between D2D based V2V links amongst vehicles. The V_T and its related V_R form VANET which repeatedly use the same spectrum of cellular network. the Cellular users have access to only cellular network however V_R have capability to switch from cellular to VANET and vice-versa. A single V_T can distribute localised information with surrounding V_R or send messages to the closest B_S making use of air medium. Messages that are sent to the ground server, which collects and helps in keeping a record of current information regarding each and every B_S and V_T which are used in controlling D2D based V2V, B_S operational switching and regulation of traffic. Consider that there are $'\ell'$ number of B_S and V_T given by $i=1,\dots\dots,\ell$. Cellular users and V_R given by 'm' denoted as $j=1,\dots\dots,m$. Omnidirectional antennas transmitting with absolute power causing interference which is witnessed by a single cellular user with approximate measure from B_S and V_T because of spectrum re-use. In order to understand operational state of B_S and V_T we define an indicator $'\beta_k'$ as:

$$\beta_k = \begin{cases} 1, & B_S \; or \; V_T \quad k \; is \; in \; active \; state \\ 0, & B_S \; or \; V_T \quad k \; is \; in \; off \; state \end{cases} \tag{1}$$

Throughput for one cellular user directly depends on the function of signal interference and noise ratio (SINR) in terms of bandwidth allocation and spectrum efficiency, which is in line with the formula given by Shannon. SINR is shown by R_{ij} and is computed as:

$$R_{ij} = \frac{\beta_k T_{P_i} C_{A_{ij}}}{\sum_{M=1}^{M} \beta_M P_M H_{M_j} + \alpha^2} \tag{2}$$

In the above equation (2) T_{P_i} is transmitted power, $C_{A_{ij}}$ is channel attenuation, assuming the channel characteristic to slowly fade and then association process is executed over a short period of time. $\sum_{M=1,M\neq i}^{m} \beta_M P_M H_{M_j}$ is the received interference in totality from B_S and V_T and α^2 is simply the noise power (thermal). All cellular users and vehicles typically in an overlapped region selection approach for access is conducted with the ultimate aim being to bring out the peerless selection approach and asset distribution, when selected amount of B_S or V_T are switched off in order to maximise collective user utility. As we are aware that in VANETs there is high movement of vehicles due to which the delay impact between two vehicles in concern should guarantee V2V services and applications. Delay in transmission can be defined as passing time for a given message from source to destination for a given VANET, this is closely related to distance of transmission amongst two vehicles. Delay in performance is meagrely satisfied when distance between source and destination is very long. Thus, it becomes crucial to disrupt the relation between transmission delay and distance respectively. By making uses of theoretical equations (3) and (4) a relationship can be declined between transmission delay and distance. Total time available is divided into time slots $(t \epsilon n)$, transmission delay is computed only along one direction. For each given time slot vehicles are located using Poisson Point. $'Y_D'$ denotes vehicle location D of a vehicle. Transmission distance between two vehicles A and B is given by $L_{A,B} = \| Y_A - Y_B \|$, here $\|.\|$ is Euclidean norm. Then delay in transmission from a vehicle A to vehicle B is

$$D_T(A,B) = T(A) - T(B) = \sum_{g=A}^{B-1}[T(g+1) - T(g)] \tag{3}$$

Now here $D_T(A,B)$ is delay in transmission from vehicle A to B. T(g) denotes time at which a vehicle g receives message. A given vehicle g is located within interval position $Y_A \; to \; Y_B$. Now assuming $C_1(t)$ and $C_0(t)$ denote probability of connection and disconnection at given instance of time(t) and we know that vehicles are using poisson point for marking their location which is static at any point in time, $C_1(t)$ and $C_0(t)$ are absolute values of time (t) therefore can be written as C_1 and C_0. The relationship between delay and distance with respect to transmission can be stated as a linear relationship, $Q = D_T(A,B)/L_{A,B}$ where Q is constant. Now in order to prove the above mentioned statement ergodic theorem proposed in (Nam et al., 2015) is used. $\{Z_{m,n}\}$ is suppose a collection of random variables, satisfying $0 \leq m \leq n$. Then (Nam et al., 2015) makes assumptions that

(i) $Z_{l,n} \leq Z_{l,n} + Z_{m,n}$ when $0 \leq l \leq m \leq n$.
(ii) $\{Z_{m+1,n+1}, 0 \leq m < n\}$ is same as $\{Z_{m,n}, 0 \leq m < n\}$.
(iii) For every n, $F|Z_{0,n}| < \infty$ and $F(Z_{0,n}) \geq -hn$ where h is constant. All the above conditions when satisfy it concludes that $Z = \lim_{n \to \infty} Z_{0,n}/n$ is true.

$$F\big(D_T(g,g+1)\big) = \int_0^\infty P\{D_T(g,g+1) = t\}dt = \int_0^\infty (C_o)^{t-1} C_1 dt = -\frac{C_1}{C_0 ln(C_0)} \tag{4}$$

$$Q = \lim_{L_{A,B} \to \infty} \frac{F(D_T(A,B))}{L_{A,B}} = \lim_{L_{A,B \to \infty}} \frac{F(\eta_{A,B} - 1) F(D_T(g,g+1))}{L_{A,B}} = -\frac{\lambda C_1}{C_0 \ln(C_o)} \tag{15}$$

Now in order to prove that the model proposed in this paper satisfies the theorem mentioned in (Nam et al., 2015), we assume that all vehicles present in 1-dimensional space inside a triangle constituting of 1, m and n. messages delivered from $\omega_l to \omega_n$ and then from ω_m to ω_n which means $D_{T_{l,n}} \leq D_{T_{l,m}} + D_{T_{m,n}}$. If vehicles 1, m and n lie on a straight line then $D_{T_{l,n}} = D_{T_{l,m}} + D_{T_{m,n}}$ this satisfies the condition one. Second condition i.e. vehicle dissemination is based on poisson point which is static having density λ at time (t) is automatically satisfied. Last condition $F|D_T(0,k)| = F\big(n_{0,k}\big) F(D_T(g,g+1))$ where $n_{0,k}$ is number of vehicles between internal $V_0 to V_n$. Now as vehicles have Poisson distribution density λ, $F\big(n_{0,k}\big) = L_{0,k} \,.\, \lambda - 1$. Then

$F(D_T(g,g+1))$ needs to prove that $P\{D_T(g,g+1)<\infty\}=1$. Now the above mentioned statement can be re-written as $1-P\{D_T(g,g+1)\}=\infty$ and this can be re-written as $1-C_0^{\infty} = > 1$ this concludes that $F\{D_T(g,g+1)<\infty\}$. When $S>0$, $F(D_T(0,n))$ is positive (+) more than any negative (-). This satisfies the third condition as well. From the above made statements we can obtain the conclusion that $Q=\lim_{L_{A,B}\to\infty} D_T(A,B)/L_{A,B}$. The expected value of D(g,g+1) is calculated by equation (4) and completed expression for Q is given by equation (5). Vehicles are assigned using poisson point with density λ then $L_{A,B}$ is distributed exponentially with density λ.

$$C_1 = P\left(L_{A,B} \le r\right) = 1 - e^{-\lambda r} \tag{6}$$

where r is transmitter range

$$C_0 = 1 - C_1 = e^{-\lambda r} \tag{7}$$

The relationship between transmission distance and delay in transmission is given as:

$$D_T(A,B) = -\frac{\lambda C_1}{C_0 \ln(C_o)} L_{A,B} = \frac{1-e^{-\lambda r}}{re^{-\lambda r}} L_{A,B} \tag{8}$$

Now assuming a single hop transmission delay for Device to Device (D2D) based V2V is given by D_T then the distance of transmission between V_T and V_R is less than L_T and is given by:

$$L_t = mi\,n\left\{\frac{re^{-\lambda r}}{1-e^{-\lambda r}} D_{t,r}\right\} \tag{9}$$

Any vehicle in the network can opt Device to Device (D2D) based V2V communication however only vehicles which fulfil the criteria that distance from V_T is within L_T can make the selection of their own mode of transmission between VANET and cellular network. The throughput that can be achieved by one cellular user is:

$$r_{ij} = S_{ij} \log\left(1 + U_{ij}\right) \tag{10}$$

Here, S_{ij} is bandwidth for one cellular user. Only one B_S or V_T is selected after processing of access request. Association indicator is proposed to show the relationship as:

$$\eta_{ij} = \begin{cases} 1, & B_S \ selected \ by \ V_R \\ 0, & otherwise \end{cases} \tag{11}$$

The main aim is to maximise the collective network benefits which include cellular users and V_R. If collective throughput is taken as objective users having exceptional channel aspect will gain most bandwidth while faded users may not even get satisfactory service, which would lead to un-balanced allocation of resources. Exceeding to the linear function log function is regarded as an appropriate fitness function, which in true terms would imitate back the required level of satisfaction owing to its continuity. This property indicates just bandwidth distribution among cellular users and V_R. This results in user utility maximization problem to be formed as:

$$max_{S_{ij}\alpha_i\eta_{ij}} \ \sum_{j=1}^{N} \log(\sum_{i=1}^{M} \eta_{ij}\, \alpha_i S_{ij} \log\left(1 + U_{ij}\right) \tag{12}$$

$$\sum_{j=1}^{N} \eta_{ij} S_{ij} \leq G_i \tag{13}$$

$$\sum_{j=1}^{N} \eta_{ij} r_{ij} \leq H_i \tag{14}$$

$$\sum_{j=1}^{N} \eta_{ij} = 1\,, \ \forall\, j \in cellular\ user \tag{15}$$

$$\sum_{i=1}^{M} \eta_{ij} = 1\,, \ \forall\, j \in V_R \tag{16}$$

$$\left\|\omega_i - \omega_j\right\| \leq L_t\,, \quad \forall j \ \in \ V_T \tag{17}$$

$$\alpha_i \ \in \ \{0,1\}, \quad \forall i \tag{18}$$

$$\eta_{ij} \ \in \ \{0,1\}, \quad \forall i\, \forall j \tag{19}$$

Equation (13) stresses the fact that the total bandwidth utilization for a given B_S should not be more than the bandwidth available (G_i). Equation (14) explains that total capacity for a given B_S achievable cannot exceed at any point in time with capacity of tolerance (H_i), the rate being r_{ij} is computed in equation (10). Equation (15) shows association of a single cellular user selection with only one B_S at given instance of time. M_{B_S} is simply the total number of B_S. Equation (16) define that V_R serviced by corresponding V_T should be located in the region having radius L_t and V_T is set of V_R. Equation (18) and (19) by way of indicators α_i and η_{ij} show binary values. Now as α_i and η_{ij} have binary values with S_{ij} being a continuous variable, peerless selection is considered as a varied integer programming problem of non-linear type which is NP-hard (Puspitorini et al., 2017). α_i, η_{ij} and S_{ij} are combined as constraints for resource and capacity making the entire scenario more complex. In order to solve such NP-hard problems brute-force cannot be used because complexity is very high. This makes the computation almost impossible even for a moderately sized network. Owing to the highly complex nature, it makes us to look for a dissemination algorithm, which has low complexity especially in case of larger networks.

3. Asset Distribution and Peerless Selection Approach

In order to minimize complexity in computing a two-step algorithm is proposed which formulates peerless selection approach and asset distribution as an aggregate of user's utility maximization problem taking into consideration that all the cellular B_S and V_T are in active state initially and reduction in power is conducted later on. Using Kuhn-Tucker the optimization problem cannot be resolved and also because it is not convex in nature as it has binary values. However, convex optimization does provide a durable method for approximation by means of dual decomposition. In comparison to giving a common solution having huge amounts of complexity, by making use of dual decomposition one can obtain a two-step solution with iteration in order to simplify the process. In the initial step we ignore the binary variable constraint. The bandwidth is allocated to all B_S and V_T after which from the pool of candidates only the one which has the highest rate is selected. In order to keep the errors minimum simple truncation is used in case of networking (Ramakrishnan et al., 2012). Lagrangian equation (20) for the main problem is given as:

$$P = \left(S_{ij}\,, \lambda_i^b\,, \lambda_i^r\right) = -\sum_{i=1}^{M}\sum_{j=1}^{N}\log\left(r_{ij}\right) + \sum_{i=1}^{M}\lambda_i^b\left(\sum_{j=1}^{N}S_{ij} - G_i\right) + \sum_{i=1}^{M}\lambda_i^r\left(\sum_{i=1}^{N}(r_{ij} - H_i\right) \tag{20}$$

Here, λ_i^b and λ_i^r are Lagrangian variables. Dual problem can be stated in terms of λ^b and λ^r using the following equation (21):

$$D_T\left(\lambda_i^b\,, \lambda_i^r\right) = \sum_{i=1}^{M}\left(\sum_{j=1}^{N}S_{ij} - G_i\right)\lambda_i^b + \sum_{i=1}^{M}\left(\sum_{j=1}^{N}r_{ij} - H_i\right)\lambda_i^r - \sum_{i=1}^{M}\sum_{j=1}^{N}\log\left(r_{ij}\right) \tag{21}$$

where $\lambda_i^b > 0$ and $\lambda_i^r > 0$.

The property of duality states that the upper bound of a utility can be given as:

$$max_{S_{ij}}\ P\left(S_{ij}\,, \lambda_i^b\,, \lambda_i^r\right) \leq min_{\lambda_i^b \lambda_i^r}\, D_T\left(\lambda_i^b, \lambda_i^r\right) \tag{22}$$

Now as λ_i^b and λ_i^r are firmly having a value more than zero satisfying slater condition and durable duality stands true in which case the highest value of the former situation equals to the lowest value. The best possible solution S_{ij} can be attained by solving best solution for λ_i^b and λ_i^r. Now we adopt gradient method to solve the problem of duality which has two Lagrangian mutable which in turn get changed in the reverse direction of gradient $\Delta d(\lambda)$. The process is iterative in manner, with Nth iteration being:

a. In case of cellular user and V_R which receive driving signals transmitted by every B_S and V_T each signal contains λ_i^b and λ_i^r where best allocation of bandwidth can be computed using derivative of S_{ij} with '*n*' number of iterations.

$$\left.\begin{aligned} &\frac{\partial I}{\partial S_{ij}(k)} = -\frac{1}{S_{ij}(k)} + \lambda_i^b(k) + \lambda_i^r(k)\log\left(1 + U_{ij}\right) = 0 \\ &=> \ S_{ij}(k) = \frac{1}{\lambda_i^b(k) + \lambda_i^r(k)\log(1 + U_{ij})} \end{aligned}\right\} \tag{23}$$

With '*n*' number of iterations all cellular users have to select the best servicing B_S and each V_R selects the best B_S which satisfies the condition:

$$j^*(k) = max_j \frac{\log(1+U_{ij})}{\lambda_i^b(k)+\lambda_i^r(k)\log(1+U_{ij})}\ , \forall j \in \widehat{B_S} \tag{24}$$

Where $\widehat{B_S}$ is set of cellular B_S

$$j^*(k) = max_j \frac{\log\left(1+U_{ij}\right)}{\lambda_i^b(k)+\lambda_i^r(k)\log\left(1+U_{ij}\right)}\ , \forall j \tag{25}$$

Bandwidth allocation in concerned access area is given by:

$$B_{ij}(k) = \frac{1}{\lambda_i^b(k)+\lambda_i^r(k)\log(1+U_{ij})} \tag{26}$$

b. Now when B_S receives bandwidth requirement from all the cellular users as well as V_R then λ_i^b and λ_i^r are refreshed and information is reverted to cellular user and V_R.

$$\lambda_i^b(k+1) = \lambda_i^b(k) - \delta \frac{\partial D_T}{\partial \lambda_i^b(k)} = \lambda_i^b(k) - \delta\left(\sum\nolimits_{j\epsilon\psi(i)} S_{ij}(k) - G_i\right) \tag{27}$$

$$\lambda_i^r(k+1) = \lambda_i^r(k) - \delta \frac{\partial D_T}{\partial \lambda_i^r(k)} = \lambda_i^r(k) - \delta\left(\sum\nolimits_{j\epsilon\psi(i)} r_{ij}(k) - H_i\right) \tag{28}$$

Where $\psi(i)$ is set of cellular users and V_R who choose B_S. $\delta > 0$ is step size and is adjusted in order to achieve speedy merging of the whole process. The algorithm moves towards merging a certain number of iterations using the above equations (27) and (28). λ_i^b and λ_i^r could be understood as shadow concept pricing. If bandwidth increases beyond a value of threshold the associated price will also go up in order for users to link with it. Else price will decrease which in turn would attract more number of users. At each iteration the complexity of dissemination is K (MxN) and value of information exchanged is K (M+N) here K is total number of cycles. Now provided K remains relatively small the algorithm performs exceedingly well in comparison to brute force in selected scenarios. When the process iteration ends the reduction in power is computed which has corresponding indicator as α_i whose value is 0 or 1. As defined in (Sehrish et al., 2013) condition that assures merger of the dual problem is given as a derivative of $D_T(\lambda)$:

$$\frac{\partial D_T}{\partial \lambda_i^b(k)} = \sum\nolimits_{j\epsilon\psi(i)} S_{ij}(k) - G_i \tag{29}$$

$$\frac{\partial D_T}{\partial \lambda_i^r(k)} = \sum\nolimits_{j\epsilon\psi(i)} r_{ij}(k) - H_i \tag{30}$$

In case of optimization problem $\sum j\epsilon\varphi(i)S_{ij}$ and $\sum j\epsilon\varphi(i)r_{ij}$ are bounded in range [0, G_i] and [0, H_i] which means derivative of $D_T(\lambda)$ will also be bounded as:

$$stu_k\{\|\partial D_T(\lambda)\| \le H \tag{31}$$

Where H is scalar in nature and satisfies condition proposition as given in (Sehrish et al., 2013). This means that assurance can be given for decomposition algorithm, which tends to merge in order to give a partial effective solution.

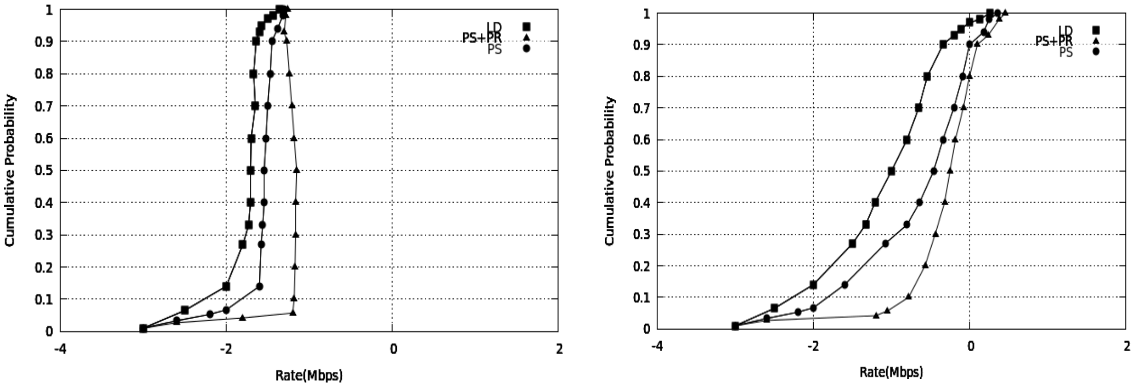

Figure 2. Throughput gain using different schemes with $\boldsymbol{\eta = 1/4}$ and $\boldsymbol{\eta = 1/2}$

4. Simulation Analysis

Simulations have been conducted in NS3 and SUMO in order to demonstrate the working of the algorithm proposed. Now assuming a typical macro-cell which has a frequency equivalent to 2.1 Ghz on which it works. The region of simulation is limited to 1.24 X 1.24 (miles). Distance between two sites is 500 mtrs and 70 B_S are deployed within the region.

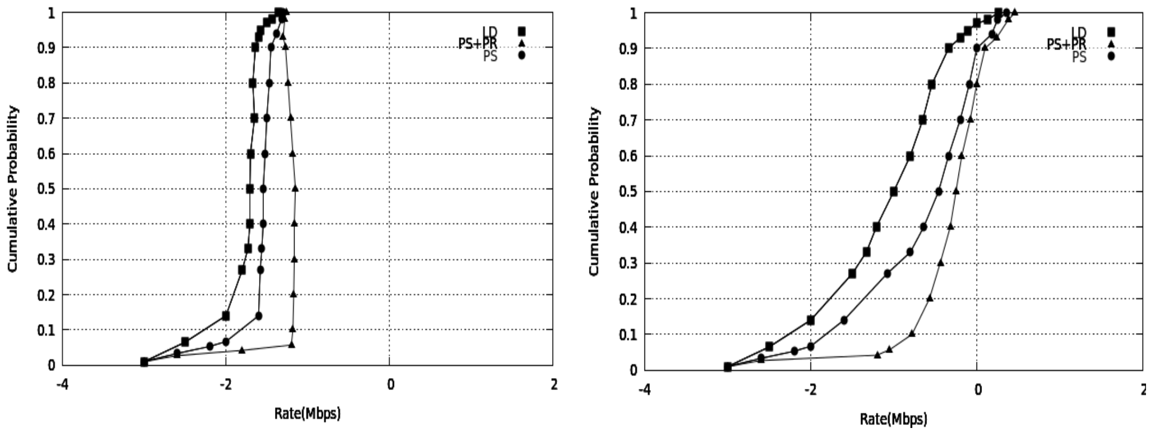

Figure 3. Throughput distribution with different schemes using different densities $\boldsymbol{\lambda = 0.01}$ **and** $\boldsymbol{\lambda = 0.02}$ respectively

The models for channels are provided by METIS as introduced in (Song and Tao, 2017) with different types of propagation. Two scenarios are explained one for cellular links and the other for vehicular links and are referred to as #3 and #4 respectively. Other parameters used in the simulation are: transmission power which has a value of B_S = 45 dBm and V_T = 20 dBm. The height of antenna is 12m for B_S and 2.5 m for V_T**.** The provided bandwidth and capacity for every V_T is 50 Mbps. The thermal noise value is at -104dBm with the delay in a transmission having boundary value of 100ms with a transmission range of a given V_T being around 20m. 1300 cellular users are distributed including V_R, vehicles are moving on roads both sides with density λ vehicles/m and remaining are cellular users. It is considered in simulations that all cellular users are haphazardly placed and all the vehicles are haphazardly distributed on the road and vehicles move mutually having their own speed, which varies with cycles. Cycles simply show the minimal value for asset regulation for radio as an association to a given user and handoff, management of energy and so on. For each road a selected size of vehicles is taken into consideration for V_T measured by ratio η. The vehicle density λ, ratio η and number of roads (N_R) are used as variables.

Table 1. Throughput Comparison between different schemes under different η

Scenario	**Location Dependent (LD)**	**Peerless Selection (PS)**	**Peerless Selection with Power Reduction (PS+PR)**
$\eta = 1/4$	610.6	917	1291.5
$\eta = 1/2$	628.5	935.2	1689.3

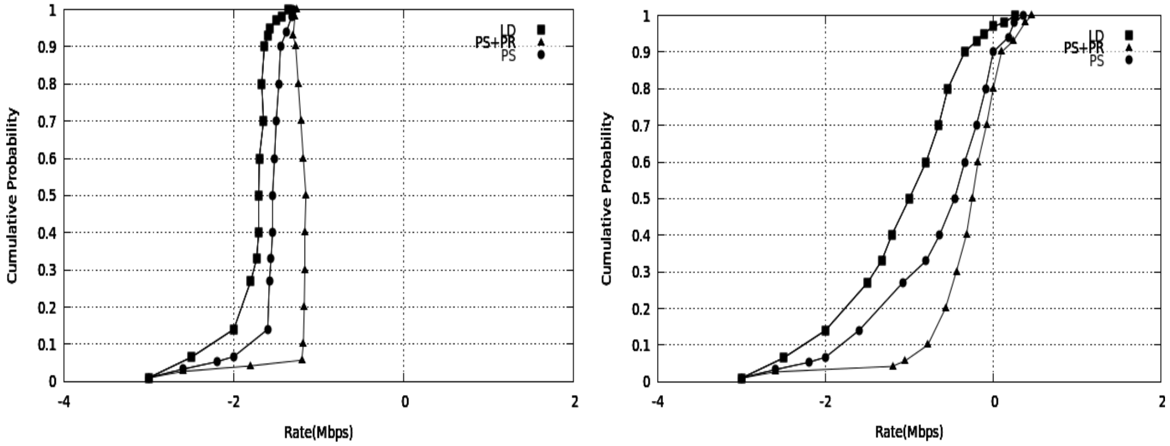

Figure 4. Throughput dissemination among schemes having varied road scenario **$N_R = 30$ and $N_R = 60$** respectively

Throughput performance is compared under varied scenarios namely location dependent asset distribution (George and Venugopal, 2012), peerless selection without reduction in power and peerless selection with reduction in power which are denoted as LD, PS and PS+PR respectively. In case of location dependent scheme manual trials having varied division ratio are determined. By changing parametric values, we can assess the influence of corresponding parametric values such as η, λ and N_R on throughput. Shows distribution of throughput between schemas having varied ratio between value of V_T and vehicles in totality. N_R value is stationary and set at 30 and λ equals to 0.02 vehicles/m. At the end of sixteen iterations merger is seen in Figure 2 with substantial throughput gain considering only 5% of cell edge and total throughput of $\eta = 0.25$. Gain in throughput becomes more prominent when V_T count is doubled as shown in Figure 2. Table 1 depicts collective throughput of different schemas. The PS shows 23% gain in throughput with $\eta = 0.25$. When PS is combined with PR and all idle B_S and V_T are turned off 41% gain is achieved in comparison to without PR. The gain in throughput is even higher with $\eta = 0.5$ going up to 121%. Large gain is seen due to cellular users which select the best possible mode for approach and attaining maximum throughput without compromising on asset distribution equity, turning off idle B_S and V_T that hinder the throughput contributions towards improvement and lead to avoiding interference with enhanced throughput. However, LD can help reduce interference improves on SINR and in turn lower spectrum efficiency utilization and ultimately limits throughput gains. As shown in Figure 3 throughput distributions in the above mentioned schemes having different density λ is compared to N_R equals to 30 and $\eta = 0.5$. High vehicle density λ means more number of V_T ultimately resulting in more complex interference scenario. Now as λ will increase delay distance between any pair of vehicles will decrease. We observe substantial gains in the scenario of 5% cellular edge and total throughput. Table 2 shows a total gain of 81% in throughput in case of the PS+PR scheme in comparison to when $\lambda = 0.01$ vehicles/m.

Table 2. Throughput Comparison between different schemes under different $\boldsymbol{\lambda}$

Scenario	**Location Dependent (LD)**	**Peerless Selection (PS)**	**Peerless Selection with Power Reduction (PS+PR)**
$\lambda = 0.01$	466	725.8	1145.6
$\lambda = 0.02$	583.6	869.6	1647.7

The gain percentage goes up-to 117% with $\lambda = 0.0203 \frac{vehicles}{m}$ this results in the recommended schema being beneficial in throughput gain, also in scenarios of high vehicle density. Figure 4 depicts throughput dissemination amongst schemes having varied road numbers N_R. λ and η Set to 0.01 vehicles/m and 0.5. Road complexity is identical to interference schema as total number of V_T increase with number of road. The figure clearly depicts the attained value of gain in throughput in case of 30 road and 60 road scenario. Table 3 shows throughput increases to 112% which depicts that the schema considered is suitable in varied road cases. Throughput performance is verified in a dynamic surrounding. As all vehicles move on the highway it leads to formation of an aggressive network structure therefore it becomes crucial to assess the behaviour. Peerless selection approach switch occurs at the beginning. At the end of operation of algorithm all B_S and V_T decide upon whether to continue or not in active state. While the cycle continues position of cellular user may change and vehicles may move along the highway with a predefined speed. Assuming all are disseminated haphazardly in the area and every vehicle tends to move towards a new variable position. The position is generally updated and creates a change in the network. It is assumed that N_R equals to 30 with values of λ equals to $0.02 \frac{vehicles}{m}$ and η equals to 0.25. As seen in Table 4 throughput is highest with every cycle competition which results to the fact that the scheme proposed is stable even when network is dynamic.

Table 3 : Throughput comparison between different schemes under different $\boldsymbol{N_r}$

Scenario	**Location Dependent (LD)**	**Peerless Selection (PS)**	**Peerless Selection with Power Reduction (PS+PR)**
$N_R = 30$	455.1	707.2	1118.2
$N_R = 60$	626.1	911.6	1712.7

Table 4. Throughput comparison between different schemes during five cycles (Mbps)

Cycle	**Location Dependent (LD)**	**Peerless Selection (PS)**	**Peerless Selection with Power Reduction (PS+PR)**
1	757.9	1077.8	1596.4
2	644.2	956.6	1474.7
3	595.7	869.7	1311.5
4	715.8	1047.6	1489.5
5	740.3	1082.9	1466.4

5. Conclusion

This paper studies the peerless selection approach and asset distribution problem in which each V_R is capable to take the decision of selecting the most appropriate approach among cellular network and VANET. The cellular users have their inherent best serving B_S. A two-phase algorithm is proposed which provides a near to perfect solution keeping the basis of convex optimization with dual decomposition adopted in order to provide user combined maximum utilization problem a possible solution by making the idle B_S and V_T to be switched off. This verifies that the scheme proposed achieves a substantial gain in throughput in comparison to the existing scheme with varied parameters applied.

Conflict of Interest

The authors confirm that there is no conflict of interest to declare for this publication.

Acknowledgement

The authors would like to express their sincere thanks to the referee and there valuable suggestions for the improvement of this paper.

References

Al-Kubati, G., Al-Dubai, A., Mackenzie, L., & Pezaros, D. P. (2015, June). Stable infrastructure-based routing for intelligent transportation systems. In *Communications (ICC), 2015 IEEE International Conference on* (pp. 3394-3399). IEEE.

Al-Kubati, G., Al-Dubai, A., Mackenzie, L., & Pezaros, D. P. (2014, April). Efficient road topology based broadcast protocol for VANETs. In *Wireless Communications and Networking Conference (WCNC), 2014 IEEE* (pp. 2710-2715). IEEE.

Alshaer, H. (2015, February). Securing vehicular ad-hoc networks connectivity with roadside units support. In *GCC Conference and Exhibition (GCCCE), 2015 IEEE 8th* (pp. 1-6). IEEE.

Arora, A., Rakesh, N., & Mishra, K. K. (2018). Analysis of safety applications in VANET for LTE based network. In *Networking Communication and Data Knowledge Engineering* (pp. 141-154). Springer, Singapore.

Bai, Y., Xie, D., Wang, S., & Zhong, M. (2015, October). Multi-path transmission protocol in VANET. In *Connected Vehicles and Expo (ICCVE), 2015 International Conference on* (pp. 204-209). IEEE.

Balasubramanian, A., Levine, B. N., & Venkataramani, A. (2008, September). Enhancing interactive web applications in hybrid networks. In *Proceedings of the 14th ACM International Conference on Mobile Computing and Networking* (pp. 70-80). ACM.

Bazzi, A., & Zanella, A. (2016). Position based routing in crowd sensing vehicular networks. *Ad Hoc Networks, 36,* 409-424.

Bessani, A., Correia, M., Quaresma, B., André, F., & Sousa, P. (2013). DepSky: dependable and secure storage in a cloud-of-clouds. *ACM Transactions on Storage, 9*(4), 12.

Bitam, S., & Mellouk, A. (2014). Routing for vehicular ad hoc networks. In *Bio-Inspired Routing Protocols for Vehicular Ad Hoc Networks.* 29-50, John Wiley & Sons.

Di Felice, M., Ghandour, A. J., Artail, H., & Bononi, L. (2012, July). On the impact of multi-channel technology on safety-message delivery in IEEE 802.11 p/1609.4 vehicular networks. In *Computer Communications and Networks (ICCCN), 2012 21st International Conference on* (pp. 1-8). IEEE.

Elazab, M., Noureldin, A., & Hassanein, H. S. (2017). Integrated cooperative localization for vehicular networks with partial GPS access in urban canyons. *Vehicular Communications*, *9*, 242-253.

George, K., & Venugopal, V. (2012, May). Design and performance measurement of a high-performance computing cluster. In *Instrumentation and Measurement Technology Conference (I2MTC), 2012 IEEE International* (pp. 2531-2536). IEEE.

Han, B., Hui, P., Kumar, V. S., Marathe, M. V., Pei, G., & Srinivasan, A. (2010, September). Cellular traffic offloading through opportunistic communications: a case study. In *Proceedings of the 5th ACM Workshop on Challenged Networks* (pp. 31-38). ACM.

Jemaa, I. B., Shagdar, O., Martinez, F. J., Garrido, P., & Nashashibi, F. (2015, January). Extended mobility management and routing protocols for internet-to-VANET multicasting. In *Consumer Communications and Networking Conference (CCNC), 2015 12th Annual IEEE* (pp. 904-909). IEEE.

Khaitiyakun, N., Sanguankotchakorn, T., & Tunpan, A. (2014, February). Data dissemination on MANET using content delivery network (CDN) technique. In *Information Networking (ICOIN), 2014 International Conference on* (pp. 502-506). IEEE.

Malandrino, F., Casetti, C., Chiasserini, C. F., & Fiore, M. (2012, June). Offloading cellular networks through ITS content download. In *Sensor, Mesh and Ad Hoc Communications and Networks (SECON), 2012 9th Annual IEEE Communications Society Conference on* (pp. 263-271). IEEE.

Mershad, K., & Artail, H. (2013). A framework for secure and efficient data acquisition in vehicular ad hoc networks. *IEEE Transactions on Vehicular Technology*, *62*(2), 536-551.

Mershad, K., Artail, H., & Gerla, M. (2012a). We can deliver messages to far vehicles. *IEEE Transactions on Intelligent Transportation Systems*, *13*(3), 1099-1115.

Mershad, K., Artail, H., & Gerla, M. (2012b). ROAMER: Roadside Units as message routers in VANETs. *Ad Hoc Networks*, *10*(3), 479-496.

Mostafa, A., Vegni, A. M., Singoria, R., Oliveira, T., Little, T. D., & Agrawal, D. P. (2011, August). A V2X-based approach for reduction of delay propagation in vehicular Ad-Hoc networks. In *ITS Telecommunications (ITST), 2011 11th International Conference on* (pp. 756-761). IEEE.

Nam, J., Min, S., & Kim, S. (2015). Extended wireless mesh network for VANET with geographical routing protocol. *11th International Conference on Wireless Communications, Networking and Mobile Computing (WiCOM 2015).*

Puspitorini, O., Siswandari, N., Mahmudah, H., & Wijayanti, A. (2017). Measurement of interconnecting network for roadside unit placement on cellular network to support intelligent transportation system. *Asian Journal of Applied Sciences*, *5*(2), 247-258.

Ramakrishnan, L., Canon, R. S., Muriki, K., Sakrejda, I., & Wright, N. J. (2012). Evaluating interconnect and virtualization performance for high performance computing. *ACM SIGMETRICS Performance Evaluation Review*, *40*(2), 55-60.

Sehrish, S., Mackey, G., Shang, P., Wang, J., & Bent, J. (2013). Supporting HPC analytics applications with access patterns using data restructuring and data-centric scheduling techniques in MapReduce. *IEEE Transactions on Parallel and Distributed Systems*, *24*(1), 158-169.

Song, W., & Tao, X. (2017, September). Analysis of a Location-Aware Probabilistic Strategy for Opportunistic Vehicle-to-Vehicle Relay. In *Vehicular Technology Conference (VTC-Fall), 2017 IEEE 86th* (pp. 1-6). IEEE.