

A Novel Quality of Service Based Data Dissemination Scheduling Approach in Vanet

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Abstract: Data services for in-vehicle consumption are expected to become a primary driver in the development of future vehicular networks. Recent research shows the inter-vehicle data dissemination problem based on a Wireless Access in Vehicular Environment (WAVE) 1/ 802.11 physical vehicular ad-hoc network, using a network coding. But still the research needs to improve the Quality of Service (QoS) and maximization of the throughput to achieve the resource reservation and sufficient vehicle to vehicle infrastructure. In this work, an efficient packet scheduling scheme, where the trade off channel condition and QoS is factored according to the user traffic. It can be performed by adding the exponent term to the part of DRC (Data Rate Control) which indicates the channel condition, in the modified proportional fair algorithm. The proposed scheme significantly outperforms existing techniques in terms of the parameters like network throughput and energy consumption. An experimental result of the proposed schema shows the enhancement of overall throughput in Vehicle-to-Vehicle (V2V) communication without violating the QoS metrics.

Keywords: Vehicular Ad-Hoc Networks (Vanets), Vehicle-to-Vehicle communication (V2V), Data dissemination, Scheduling Algorithm.

1. INTRODUCTION

Wireless communication in Vanets enables information exchange between Vehicle-to-Vehicle (V2V) and Vehicles-to-Roadside Infrastructure (V2I). Since vehicles are moving, network topology is constantly changing. VANETs are highly dynamic and have most characteristics of Mobile Ad-Hoc Networks (MANETs) [1-2]. There are numerous applications in the domain of VANETs that are used for different purposes like improving safety, driving and commercial services. Vehicular networks differ from conventional ad-hoc wireless networks by not only experiencing rapid changes in wireless link connections; but also deals with different types of network densities [3]. Consequently, routing and dissemination algorithms become efficient and should adapt to vehicular network characteristics and applications. Until now, most of the vehicular network research has focused on analyzing routing algorithms to handle the broadcast storm problems in a highly dense network topology. Under the oversimplified assumption that vehicular network is a well-connected network in nature [4-5].

The data exchanged between vehicles generated by sensors, which are embedding on the vehicles by other external data source. Broadcasting is a very expensive dissemination technique which consumes channel communication capacity and also increases the collision and packet losses [6]. Vehicles in same proximity are helpful for detecting road warning, collision warning and emergency warning which inevitably broadcast messages relating to the incident supposed to be happen [7].

Figure 1. shows a group of vehicles in geographic vicinity that have a common interest in some data on the Internet, such as traffic surveillance video, map updates and other geo-related information. For the purpose of

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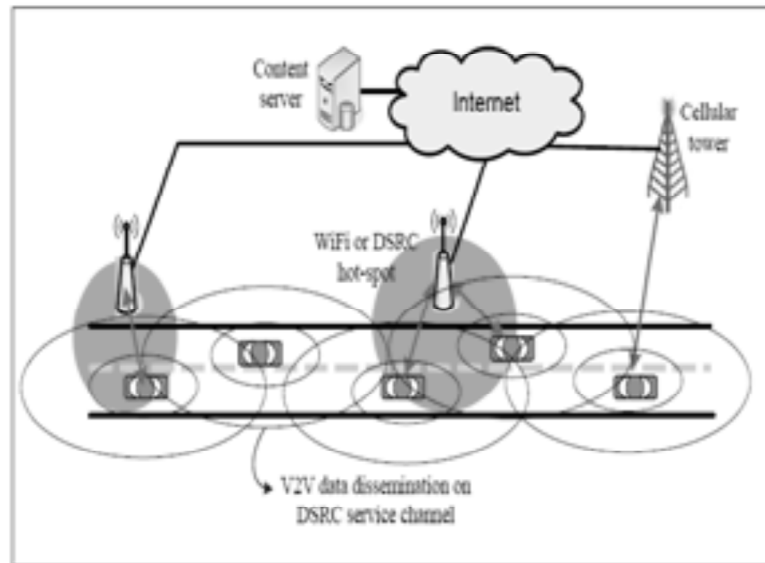


Figure1. Inter-vehicle horizontal data dissemination supplements vertical direct downloading

lightweight data exchange, packets in WAVE (Wireless Access for Vehicular Environments) can be transmitted as 1-hop broadcast with no feedback as defined in IEEE802.11p is specified in IEEE P802 (2008)[8]. In V2V communication number of vehicles likes to access data through roadside unit, therefore data scheduling become an important issue. It analyzes the multicast throughput of Network Coding (NC) that aided content distribution in a linear Vanet.

Networks must provide secure, predictable, measurable and sometimes guaranteed services. Achieving the required Quality of Service (QoS) by managing the delay, delay variation (jitter), bandwidth, and packet loss parameters on a network becomes the secret to a successful end-to-end business solution. Quality of service (QoS) guarantees in Vanet is much more challenging due to the high mobility of its mobile hosts, multi-hop communications and contention for channel access. High levels of QoS in traditional networked environments can often be achieved through resource reservation and sufficient infrastructure. The main goal of this paper is to improve the overall throughput and analyze the quality criteria which are achieved using Data Rate Control (DRC) which indicates the channel condition in the modified proportional fair algorithm.

2. RELATED WORK

Peer-to-peer collaboration via vehicular communication is explored in [9-10] for content sharing. SPAWN, a swarming protocol for vehicular ad-hoc networks was proposed in [19] to extend wired Internet peer-to-peer content distribution protocols (e.g., Bit Torrent) to Vanet. However, peer discovery and peer & content selection processes have high overhead due to Vanet's dynamic nature. The assumption of reasonable transport layer bandwidth in [9] does not fit into the WAVE broadcast paradigm. Similar observation was made in [10] for Code Torrent, a NC aided file swarming protocol with no underlying routing support.

NC has been applied to the full data dissemination problem [11] and the reliable multicasting problem [12]. In [11], each node has some packets to share with all other nodes, and a gossip based algorithm is used to diffuse information in the ad hoc network that is optimized for energy efficiency. In [12] reliable multicasting in a single cell wireless network and a tree topology constructed by using several cells. In each cell, coded packets are repeatedly broadcast by an access point, till all nodes have correctly received the packets. During the last few years, a lot of broadcasting protocols for VANETs have been reported in the literature. They can be generally classified into two main categories according to the spreading of information in the network. These categories are [13] single-hop broadcasting and multiple-hop broadcasting.

Dedicated short range communication (DSRC) band for Intelligent Transportation System (ITS) is used to enable communication-based safety and infotainment services ASTM (2003)[14]. In Europe, different frequency bands are used for vehicular communications, for instance, unlicensed frequency band at 2010–2020 MHz is used in Fleetnet is explored in [11]. Disseminating traffic information in Vanet is a critical problem. In contrast to other networks such as Internet where data is typically unicasted, the traffic information has a nature which requires broadcasting [15]. Traffic information is destined for public interest, and not only for an individual. Broadcasting scheme has the advantage that a vehicle does not require the destination address and the route to a particular destination. As a result it reduces the various difficulties in Vanet such as complexity of route discovery, address resolution and topology management.

In contrast, the V2V data dissemination is a one-to-many dissemination process in this work. While [16] [17] explores the design via simulation, thus work provides analytical results for V2V data dissemination under a simple scheduling model [17] analyzes the multicast throughput of NC aided content distribution in a linear Vanet.

Data dissemination in VANETs has become an active research area in recent years. A number of researchers have contributed several novel and efficient techniques for data dissemination. The thorough investigation on data dissemination techniques in Vanets is explored in [5]. The characteristic features of the data dissemination techniques available in the literature have been thoroughly analyzed for the betterment of the data dissemination. In this paper, results from extensive set of simulations are presented to measure the impact of adaptable parameters that govern QoS and also measure the overall throughput in Vanets are achieved using DRC which indicates the channel condition in the modified proportional fair algorithm. Moreover simulations in this paper are performed using enhanced 802.11 NS-2 [18] modules that provide more realistic communication thus furnishing more accurate results.

3. PROPOSED METHODOLOGY

Network coding (NC) leverages the unexploited redundancies due to the broadcast nature of wireless networks for more efficient data dissemination. The network coding based system is defined, before performing the scheduling strategy in V2V communication. Packet scheduling strategy is performed, where the trade-off of channel condition and QoS is factored according to the user traffic. Thereby, overall throughput can be increased with the graceful QoS degradation of users under severe channel condition. It can be performed by adding the exponent term to the part of DRC which indicate the channel condition in the modified proportional fair algorithm.

3.1. Linear Network Coding

A Linear network coding is a block code conducted over finite field $\mathbb{F}q$, where q is the finite field size. Every packet x_i consisting of $\log(q)$ —bit symbols, can be treated as a vector in $\mathbb{F}q$, during any transmission, the source broadcasts a linear combination of all M , packets it has stored x_1, x_2, \dots, x_M

$$y_i = \sum_{k=1}^M \gamma_{i,k} X_k \quad (1)$$

where γ_{ik} are the random NC coefficients selected uniformly in $\mathbb{F}q$, at the i th transmission. The received coded packet at a receiver can be expressed as a linear combination of the M original packets in the network, regardless of the actual sender of the packet. Specifically, if a node receives K coded packets can be written in the following vector product form,

$$Y_{k \times 1} = A_{k \times M} X_{M \times 1} \quad (2)$$

Where $A_{k \times M}$ is the coefficient matrix containing all NC coefficients. In the case $K \geq M$, the matrix A is full rank almost surely due to random choice of NC coefficients from $\mathbb{F}q$ and the receiver can recover the original data set $X = A^{-1}Y$. For decoding, clearly the receiver needs to know the NC coefficients A used during all transmissions. It

allows the \mathbb{F}_q transmitter to embed these coefficients in each packet. The linear NC of M packets over finite field needs $M \log_2(q)$ -bit long coefficients in each packets.

3.2. Scheduling Strategy

The idea behind, this strategy lies on the simple observation, that a successful file downloaded by all the users in the scheduling mode requires repeated transmissions of the same packet. Therefore at the beginning of the second transmission of a packet, there exist additional spatially dispersed nodes that can decode the packet successfully with high probability. Initially (at time $t = 0$) there is a single file (M packets denoted by $x_1 \dots x_M$) at a single source node (vehicle) to be disseminated to all other vehicles in a single direction. Packet data transmission is used to utilize the resource effectively and support the high transmission rate max CIR (carrier to- interference ratio) scheme, which focus on one side of the fair and channel condition. A proportional fair algorithm is suggested by considering the channel condition and the fairness of the channel effectively, where a user with better channel condition is utilized through proposed modified proportional fair algorithm.

3.3. Modified Proportional Fair Algorithm

The max CIR rule, an algorithm based on priority, would schedule the user whose channel can support the largest data rate. Though, the rule can be the best solution to maximize the system throughput, the problem of the fairness can arise. In High Detection Rate (HDR) system, the system throughput and fairness is effectively balanced, is suggested in [11], [5]. The version of this rule is given by,

$$j = \arg \max_i \frac{DRC_i(t)}{R_i(t)} \quad (3)$$

Where j is the selected user for the next time slot, N is the number of the users, $DRC_i(t)$ is the DRC at slot t for user i and $R_i(t)$ is the average received slot t . This algorithm gives equal allocation time to users, which is differing in the mean path loss. Their fading characteristics provided will supply equal energy during transmission; also it takes advantage of channel variations by selecting with the higher probability were the channel condition is relatively better than the average value for each user.

3.4. DRC Exponent Rule

The modified proportional fair algorithm can make a good comprise between the throughput and the fairness, where the weighting factors of the throughput and the fairness are given in (3). The system could be operated more efficiently by changing the parameter. DRC of user i is $a_i b_i(t)$, where a_i is the average DRC and $b_i(t)$ is the variant component of the DRC of each user from slot to slot. The Packet Delivery Factor (PDF) of $b_i(t)$, is assumed to be chi-square, so the PDF of $DRC_i(t)$ is given by,

$$p_x(X) = \frac{1}{2a_i'} e^{\frac{-x}{2a_i'}} \quad (4)$$

Scheduling and transmission is performed at every slot, hence the data transmission is effectively performed. Throughput of user k is considered to be stationary (with the throughput of infinite length). It can be classified as two groups,

$$DRC_{1,j}(t) = a_1' b_{1,j}(t), j = 1, \dots \dots N_1 \quad (5)$$

$$DRC_{2,j}(t) = a_2' b_{2,j}(t), j = 1, \dots \dots N_2 \quad (6)$$

Because the users in the class have the same independent distribution, the stationary throughput converged to the same value. Let the values be T_1 and T_2 for each class and r is the ratio $\left(\frac{T_1}{T_2}\right)$, then the ratio of the total class throughputs are represented as,

$$\frac{T_1 N_1}{T_2 N_2} = \frac{P(X_1 > r^n X_2) E[X_1 | X_1 > r^n X_2]}{P(X_2 > r^{-n} X_1) E[X_2 | X_2 > r^{-n} X_1]} \quad (7)$$

Where $X_1 = \max_j \{a'_1 b_1, j(t)\} j = 1, \dots, N_1$ $X_2 = \max_j \{a'_2 b_2, j(t)\} j = 1, \dots, N_1$

The PDF of the X_1 and X_2 can be obtained as,

$$f_{x_i}(X_i) = \frac{d(F_{x_i}^{N_i})}{dx} = -a_i \sum_{k=1}^{N_i} A_k e^{-ka_i x} \quad (8)$$

Then the numerator of $f(r)$ is evaluated as

$$N = N_2 \int_0^{\infty} a_2 \sum_{l=1}^{\infty} A_l e^{-la_2 x} \quad (9)$$

By the similar manner, the denominator is represented as

$$D = a_1 N_1 \sum_{k=1}^{N_1} \sum_{l=1}^{N_2} A_k A_{l,k} \left(\frac{2a_2 l r - \frac{1}{n} + a_1 K}{a_2 l (r - \frac{1}{n} + a_1 K)^2} \right) \quad (10)$$

The ratio r is derived as the following equation

$$a_2 N_2 \sum_{i=1}^{N_1} \sum_{j=1}^{N_2} A_i A_j J \left(\frac{2a_1 i r - \frac{1}{n} + a_2 j}{a_1 i (a_1 i r - \frac{1}{n} + a_2 j)^2} \right) \quad (11)$$

For the some cases of $N_1 = N_2 = 1$, the following result can be obtained,

$$r = \frac{a_2}{a_1} \left[\frac{2a_1 a_2 r \frac{1}{n} + a_2^2}{2a_1 a_2 r \frac{1}{n} + a_2^2 r \frac{2}{n}} \right] \quad (12)$$

The existence of the upper bound of the ratio means, that the DRC exponent rule practically cannot approaches to the max CIR rule with increase in . So the minimum throughput for the users of worse channel condition can be retained. Best effort data traffic which utilizes asynchronous channel variation to improve the overall system throughput with considering the fairness. The proposed work of QoS for each service in the wireless networks is represented as,

$$j = \arg \max_i \frac{DRC_i(t)}{R_i(t)} f_Q(QoS_{req_i}, QoS_{cur_i}), \quad i = 1, \dots, N \quad (13)$$

where QoS_{req_i} , and QoS_{cur_i} denote the required QoS and currently serviced QoS for user i , $f_{QoS}(\cdot)$ is the increasing function for the level of the QoS requirements.

4. EXPERIMENTAL RESULTS

The simulations are performed to validate analytical results for NC based dissemination. Scheduling strategy is used to measure the QoS results in the V2V communication. Multi-access interference is used, according to scheduling model, and the receiver can decode the packet successfully if and only if it's received signal-to-noise-ratio (SNR) exceeds a decoding threshold, i.e.,

$$P_{succ} = Pr\left(\frac{\gamma_k}{n_0} \geq z\right) z > 1 \quad (14)$$

where n_0 is the noise power and z is the capture threshold whose value depends on the channel coding and modulation. The QoS of a data can be defined in different ways. In this paper, the average throughput R_i provided to user i is not less than some predefined value Q_i is concerned and let f_Q be $Q_i = R_i$. The DRC of user i $a'_i b_i(t)$ where $a'_i(t)$ is defined as,

$$a'_i(t) = i + \frac{ratio - 1}{N}, \quad i = 1, N \quad (15)$$

where N is the number of total users and ratio is a'_N / a'_1 , that is the ratio of the best averaged channel condition to the worst one, a'_1 is 1 and with one increase of user index, a'_i is increased by $\frac{ratio - 1}{N}$. If ratio is 1, a'_i is all the same as 1. The performance comparison results of the proposed DRC and the single source dissemination scenario methods in terms of the delay, energy consumption, packet delivery ratio (PDR) and throughput parameters is evaluated. The delay of the proposed DRC and existing Steady State Data Dissemination (SSDD) is measured based on the following formula,

$$\text{Latency} = \text{Propagation delay} + \text{Transmission delay} + \text{Queuing time} + \text{Processing time} \quad (16)$$

The propagation delay and transmission delay are measured based on the following formula,

$$\text{Propagation Delay} = \text{Distance} / \text{Propagation speed} \quad (17)$$

$$\text{Transmission Delay} = \text{Message size} / \text{bandwidth bps} \quad (18)$$

Where the queuing time be the number of packets waiting in the Vanet and processing time is the total completion time of the process.

Figure 2. plots the cumulative dissemination completion time versus node index. The reciprocal of the slope of the cumulative completion time curve is the average dissemination velocity. For the proposed DRC based broadcast, the simulation result closely matches to the existing NC. The NC and perfect feedback achieves about the same steady state velocity; however NC provides a better guarantee that a packet is new or innovative as compared to perfect feedback and achieves a slightly higher steady state velocity.

The PDR of the proposed DRC and existing SSDD is measured based on the following formula,

$$PDR = \frac{\sum_{i=1}^n a_i}{a_i} \quad (19)$$

a_i is the total number of packets transferred, $\sum_{i=1}^n a_i$ is the total number of packets which are correctly received for data dissemination.

Throughput: Average rate of successful packet delivery. In terms of Net Sim's metrics it is,

$$\text{throughput} = \frac{\text{no of packets transmitted} - \text{no of packets errored}}{\text{simulation time}} \quad (20)$$

The results of the proposed DRC and the existing SSDD, in terms of delay are shown in Figure-3. It shows that the delay of the proposed system is less of the proposed DRC is high when compare the existing methods it quickly performs data dissemination process in Vanet from vehicle to vehicle communication (V2V).

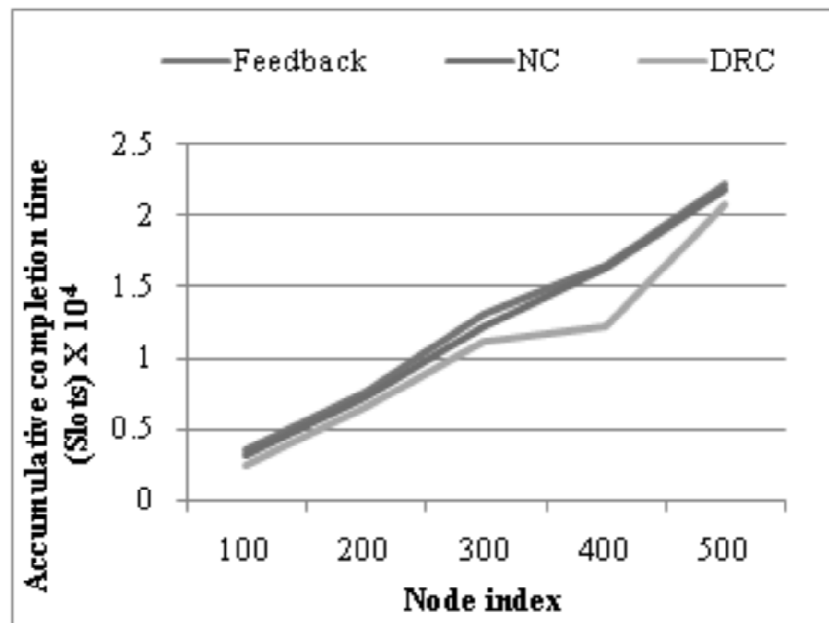


Figure 2: Cumulative dissemination completion time of all three (proposed DRC, Feedback, and NC) schemes

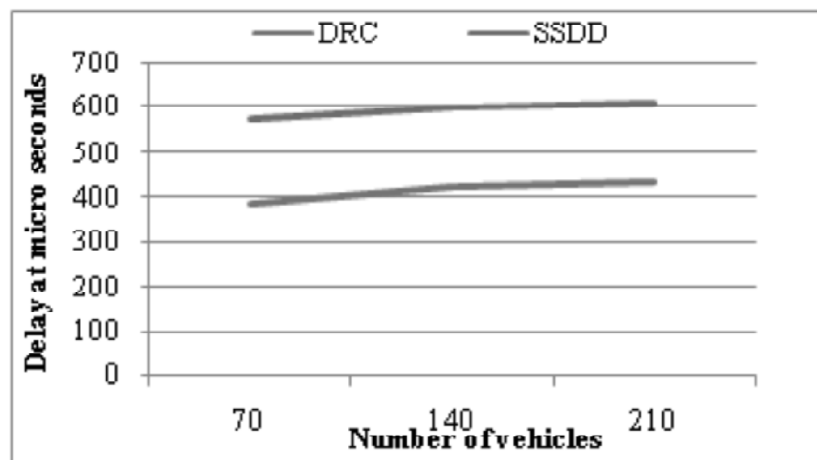


Figure 3: Delay comparison for vehicles vs. Methods

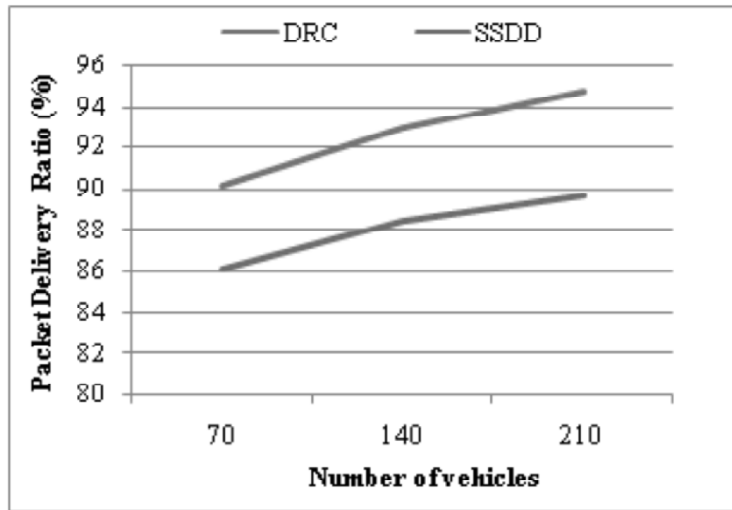


Figure 4: PDR comparison for vehicles vs. Methods

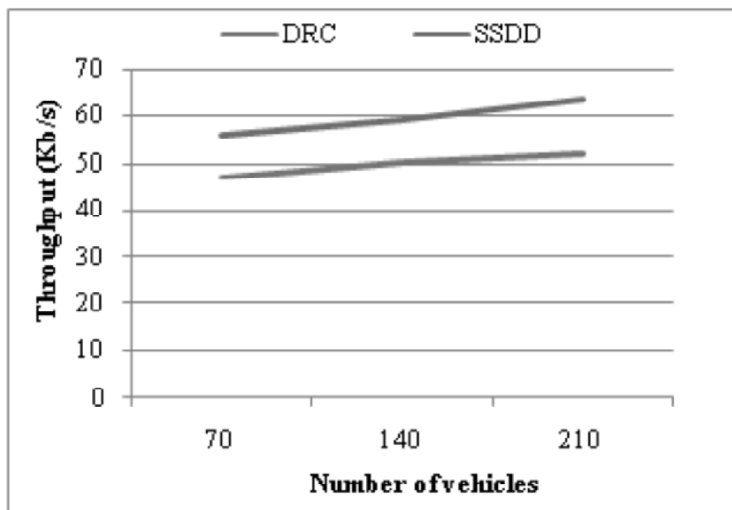


Figure 5: Throughput comparison for vehicles vs. Methods

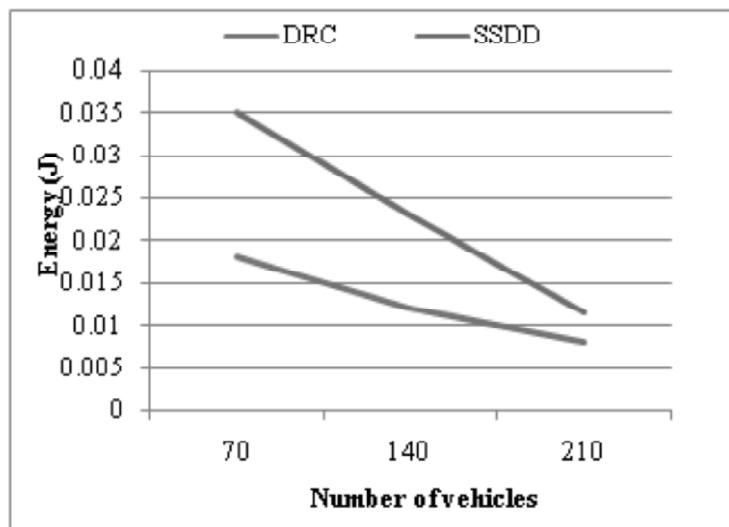


Figure 6. Energy comparison for vehicles vs. Methods

PDR results for number of vehicles are shown in Figure-4. It shows that the PDR of the proposed system is less of the proposed DRC is high when compare the existing methods it quickly performs data dissemination process in Vanet from V2V communication.

In Figure 5. the throughput of the first case is depicted. As the number of nodes (vehicles) is increases, the throughput also gets increases, reaching source to destination in data dissemination process. However, also considering simulation time of 300s seconds for 210 vehicles, if the number of vehicles taken increases the throughput achievement of the proposed DRC methods have a positive impact on throughput. On the other hand, performances get worse when the vehicles increase in the existing SSDD process.

For the validation of the effectiveness of the proposed DRC approach, the amount of energy consumed during data dissemination is compared to that of the existing SSDD is shown in Figure 6. However, also considering simulation time of 300s seconds for number of vehicles in this work to measure the amount of energy consumed in the proposed work, the number of vehicles taken for data transmission are 210 vehicles. The energy dissipated at the beginning of each nodes is less for proposed DRC when compare to existing SSDD approach. If the number of vehicles increases the energy consumption decreases, but it consumes less when compare to existing work is shown in Figure 6.

5. CONCLUSION

This work has explored horizontal peer-to-peer content distribution using V2V ad-hoc communications to supplement vertical vehicular data download from cellular and road side infrastructure. NC based broadcast reaches steady-state and derived a closed form of result during data dissemination. Modified proportional fair rule containing the DRC exponent, the proposed scheme can utilize the channel condition more effectively while guaranteeing the QoS in V2V system. Simulation results show the overall throughput of the network is maximized and QoS metrics are increased. In future we investigate the same work in the aspect of the routing and how to solve routing by applying the shortest path investigation methods and QoS parameters in the Vanet also focused based on the properties of the Vanet in V2V communication.

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