An RSU On/Off Scheduling Mechanism for Energy Efficiency Analysis of a Roadside Relay Point Deployment for Information Delivery in VANET

Er Gurpreet Kaur*, Er Aashdeep Singh
Department of Computer Science and Engineering, Kurukshetra University, Kurukshetra, Haryana, India

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Abstract—This paper considers energy efficiency of the roadside units (RSUs) in sparse vehicular networks (VANETS) and evaluates an effective on/off scheduling mechanism for increasing the energy efficiency of an RSU. In a sparse road scenario if an RSU is constantly turned on, it would cause significant energy waste. To diminish the energy consumption of RSU and increment the energy efficiency of the framework, it is important to turn OFF the RSU when there is no requirement for information transmission, and turn the RSU ON once information transmission is required. An RSU works alternately between ON and OFF in a periodic manner. An analytical model is derived to estimate the performance metrics and energy efficiency of the RSU using the ON/OFF scheduling mechanism.

Keywords—Vehicular Ad hoc Network (VANETs); Access Points (APs); Vehicle-to-Vehicle (V2V); Vehicle-to-Infrastructure (V2I); Road side units (RSU)

1. INTRODUCTION

Wireless networks have of late gained greater prevalence because of minimal cost and quick deployment. Numerous clients are utilizing wireless networks in their everyday lives. For instance, in their own homes, clients can surf the Internet by getting to an IEEE 802.11 compliant wireless router that is associated with a modem. As of late, new sorts of Wireless networks, which are called vehicular systems, have drawn serious consideration. Commonly, in vehicular systems, some wireless gadgets, for example, routers or sensors are deployed on the roadside, acting as access points (APs). Some APs are associated with gateways with direct connects to the Internet to such an extent that travelers in vehicles can appreciate different Internet services. A few cameras can likewise be mounted on the APs to screen the traffic situations and to respond to the mishaps rapidly. Likewise, vehicles can be outfitted with some wireless gadget and, consequently, can communicate with each other and in addition with roadside APs. The subsequent systems are called Vehicular Ad hoc Networks (VANETs) [1].

1.1 VANETS

A Vehicular Ad Hoc Network (VANET) is a system where every hub represents a vehicle furnished with wireless communication technology. Communication in these systems can be Vehicle-to-Vehicle (V2V), when vehicles communicate directly, or Vehicle-to-Infrastructure (V2I), when vehicles exchange information with access points called Roadside Units (RSUs), and some other system framework, for example, 3G and 3GPP Long Term Evolution (LTE). VANETs can gather ongoing information on street conditions and make them helpful for an extensive variety of uses, including safety warning systems, drivers help and traffic routing. This last data, for example, could be utilized to make vehicle routes as indicated by carbon emission levels, dodging to course certain sorts of vehicles to polluted areas. Also, this information can be utilized to make intelligent traffic management systems, which can consequently refresh activity light cycles, indicate probable urban tolling zones, study the day by day populace of vehicles on the road, etc [2].

1.2 RSU

Road Side Unit (RSU) is wireless LAN access point and can furnish communications with infrastructure. It can have higher scope of communication up to 1000m. Yet, the establishment of RSU is exceptionally costly [3]. In a VANET, RSUs are deployed to enhance network connectivity, encourage information dissemination, and access external networks. In a sparse road situation, the quantity of vehicles going through a RSU is small and in this way a RSU does not have a vast activity stack in information transmission. For this situation, if a RSU is constantly turned on, it would cause considerable energy waste during the period when there is no data traffic. To lessen the energy consumption of a RSU and increment the energy efficiency of the framework, it is important to turn off the RSU when there is no requirement for information transmission, and turn the RSU ON once information transmission is required [4].

1.3 Broadcasting and traffic monitoring in VANETS

Broadcasting in vehicular ad-hoc network (VANET) is rising as a basic zone of research. One of the difficulties postured by this issue is the restriction of the routing problem to vehicle-to-vehicle (V2V) situations rather than likewise using the wireless foundation, (for example, cell systems). At a central level, security and transport productivity is a command for
current car manufacturers and this must be given by the cars on road and about instead of moreover utilizing the current wireless communications infrastructure. Such applications with this real-world constraint, calls for a new routing protocol for vehicular broadcasting in VANET [5]. Vehicular ad-hoc networks (VANETs) have been imagined to give increased convenience and efficiency to drivers out and about. For instance, an alert message about a car crash or congested road can be proliferated several miles along the street to enable drivers to choose a superior course. Department stores can spread sale commercials to vehicles inside the region to pull in purchasers and to provide dining and parking information. Through these applications, we can see that the VANET is exceptionally helpful for spreading information from a data source (data center) to numerous vehicles out and about. In spite of the fact that spreading information from a server to countless has been considered in the database community and the network community, numerous one of a kind attributes of the VANET bring out new research challenges. To begin with, because of quick vehicle development, the connection topology changes quickly. Thus, some very much contemplated structures for effective information dispersal, for example, trees, bunching, and frameworks, are amazingly difficult to set up and keep up. Second, the conventional broadcast mechanism for data dissemination may prompt broadcast storm in light of the fact that the network node density is normally very high in an urban region and extremely dense amid surge hours or roads turned parking lots. Third, the vehicle mobility is partially predictable since it is restricted by the activity design and the street layout. Data dissemination systems ought to address these one of a kind attributes of the VANET [6].

Despite the fact that there are various traffic monitoring technologies as of now being utilized, from magnetic strips to radar detectors, an ever more prominent number of urban areas are deploying traffic cameras as their essential approach to screen traffic. Traffic cameras give a more adaptable method for checking activity and are substantially less expensive to introduce and keep up (unlike magnetic strips which require road excavation). In addition, currently deployed cameras can be controlled wirelessly with the capacity to pan and zoom around a given area, permitting observing of a more prominent range, compared to other monitoring techniques. With such abilities, not exclusively can these cameras be utilized as a part of basic tasks like counting cars and controlling traffic lights, they additionally can possibly be utilized as a part of more intricate applications like vehicle tracking. In this paper, we look at the specific use of vehicle tracking, using ubiquitous traffic cameras [7].

1.4 Different types of Network Densities
VANET not just encounters quick changes in wireless connection associations, however may likewise need to manage diverse sorts of system densities. For instance, VANETs on roads or urban territories will probably frame highly dense networks during bumper-to-bumper rush hour traffic, while VANETs are relied upon to encounter frequent network fragmentation in meagerly populated rural freeways or during late night hours. As of recently, a large portion of VANET research has concentrated on breaking down routing algorithms to deal with the broadcast storm issue in a dense network topology, under the over-simplified assumption that a typical VANET is a well connected network in nature. Conversely, it is trusted that the disconnected network problem is additionally a significant research challenge for building up a reliable and efficient routing protocol that can support highly diverse network topologies [8].

II. RELATED WORK

2.1 Optimal Placement of Gateways in VANETS
In vehicular systems, mobile clients in vehicles can get to the Internet and appreciate different sorts of administrations, for example, Voice over IP (VoIP) and web based streaming video. To provide satisfactory Quality Of Service (QOS), we have to suitably place gateways to link mobile nodes to the Internet or whatever other data systems. The issue of optimally placing gateways in VANETS to limit the average number of nodes from access points (APs) to gateways is addressed, so that the communication delays can be limited. In addition, how to limit the total power utilization is investigated, also, when the average number of hops is limited, the normal limit of each AP can be maximized [1].

2.2 RSU Deployment for Information Dissemination in a VANET
A Vehicular Ad Hoc Network (VANET) is a system where every hub communicates to a vehicle furnished with wireless communication technology. This sort of system can enhance road safety, traffic efficiency, and numerous other traffic related applications, limiting their environmental impact and augmenting the advantages of road clients. An applicable issue in VANETs, known as the deployment of Roadside Units (RSUs) is studied. A RSU is an access point, utilized together with the vehicles, to permit information dissemination on the roads. It displays the issue as a Maximum Coverage with Time Threshold Problem (MCTTP), and utilize a genetic algorithm to solve it. The calculation is tried in four real world datasets, and contrasted with a greedy approach. The outcomes demonstrate that this approach discovers preferable outcomes over the greedy in all situations, with increases up to 11 percentage points [2].

2.3 Broadcast Protocol for V2V and V2RSU in VANET
This framework consolidates algorithms suitable for areas with and without Road Side Units. It is the combination of the vehicle to vehicle (V2V) and vehicle to Road Side Unit (V2R) communication. The V2V calculation utilizes the signal messages to secure the data of the neighbors, communicate the messages and obtain affirmations. Connected dominating set (CDS) is figured and CDS nodes utilize a shorter holding up period before possible retransmission. At time out, vehicle retransmits data if there is no less than one neighbor which needs the message. The Road Side Units (RSU) has a high scope of communication. In this manner V2R disseminates data faster. RSU is likewise used to decrease the excess
retransmissions. The coordination of V2V and V2R communication is helpful because V2R provides better service in sparse networks and long distance communications, while V2V empowers direct communication for small to medium areas and at areas where roadside access points are not accessible [3].

2.4 RSU On/Off Scheduling Mechanism for Energy Efficiency in Sparse VANET
It considers energy efficiency of roadside units (RSUs) in sparse vehicular systems and proposes a basic but effective on/off scheduling mechanism for decreasing power consumption of a RSU. With the proposed on/off scheduling mechanism, if there is no request received from vehicles, a RSU works alternately between ON and OFF in a periodic manner. If a request is received from a vehicle during the ON state, the RSU will augment its ON state for a basic ON period. Otherwise, if a request arrives during the OFF state, the demand will be dropped. An analytical model is inferred to estimate the execution of the proposed scheduling mechanism in terms of the request acceptance probability and the energy efficiency of an RSU. Simulation results are additionally introduced to confirm the exactness of the derived analytical model [4].

2.5 Broadcasting in VANET
The primary finish variant of a multi-jump communicate convention for vehicular ad-hoc networks (VANET) is reported. The outcomes clearly demonstrate that broadcasting in VANET is altogether different from routing in mobile ad hoc networks (MANET) because of a few reasons, for example, network topology, mobility patterns, demographics, traffic patterns at various circumstances of the day, and so forth. These distinctions imply that conventional ad hoc routing protocols, for example, DSR and AODV won't be suitable in VANETs for most vehicular communicate applications. Three administrations that a vehicular broadcast protocol needs to work in are identified as: i) Dense traffic regime; ii) Sparse traffic regime; and iii) Regular traffic regime. Already proposed routing solutions for each regime are build and the broadcast message can be disseminate efficiently is demonstrated. The proposed outline of the Distributed Vehicular Broadcast (DV-CAST) protocol integrates the utilization of various routing solutions [5].

2.6 Data Pouring and Buffering on the Road
Vehicular ad-hoc networks (VANETs) have as of late gotten significant consideration. To bolster VANET-based applications, it is essential to spread information from a data source (data center) to numerous vehicles out and about. In spite of the fact that spreading information from a server to a substantial number of customers has been contemplated in the database community and the network community, numerous interesting qualities of the VANET bring out new research challenges. A Data pouring (DP) and buffering paradigm to address the data dissemination problem in a VANET is proposed. In DP, data is periodically broadcasted to vehicles out and about. In DP with intersection buffering (DP-IB), information poured from the source are buffered and rebroadcast at the intersections. Analytical models to investigate the dissemination capacity (DC) of the proposed scheme are provided. The analytical models additionally provide guidelines on choosing the system parameters to augment the DC under different delivery ratio requirements. Simulation results show that the proposed DP-IB plan can fundamentally enhance the data delivery ratio and reduce network traffic [6].

2.7 A Graph-Based Approach to Vehicle Tracking
Vehicle tracking has a wide assortment of uses from enforcement to traffic planning and public safety. Nonetheless, the image resolution of the recordings accessible from most activity camera frameworks, make it hard to track vehicles unique identifiers like license plates. As a rule, vehicle with similar attributes are indistinguishable from each other because of picture quality issues. Often, network bandwidth, speed and power imperatives constrain the frame rate, too. The difficulties of performing vehicle tracking queries over video streams from ubiquitous traffic cameras are talked about. The limitations of tracking vehicles independently in such conditions are identified and given a novel graph-based approach utilizing the identity of neighboring vehicles to enhance the performance. The approach is assessed utilizing streaming video feeds from live activity cameras accessible on the Internet. The outcomes demonstrate that vehicle tracking is feasible, notwithstanding for low quality and low frame rate traffic cameras. Also, exploitation of the attributes of neighboring vehicles altogether enhances the execution [7].

2.8 Routing in Sparse Vehicular Ad Hoc Networks
A Vehicular Ad Hoc Network (VANET) may display a bipolar behavior, i.e., the system can either be completely associated or sparsely associated relying upon the time of day or on the market penetration rate of the wireless communication devices. Utilization of exact vehicle movement information measured on I-80 expressway in California to build up a complete investigative system to concentrate the network phenomenon and its network characteristics. These qualities shed light on the key routing performance metrics of interest for detached VANETs, for example, the average time taken to propagate a packet to disconnected nodes (i.e., the re-healing time). The outcomes demonstrate that, contingent upon the sparsity of vehicles or the market penetration rate of cars using Dedicated Short Range Communication (DSRC) technology, the can fluctuate from a few moments to a few minutes. This proposes, for vehicular security applications, a new ad hoc routing protocol will be required as the conventional ad hoc routing protocols such as Dynamic Source Routing (DSR) and Ad Hoc On-Demand Distance Vector Routing (AODV) won't work with such long re-healing times. Furthermore, the created analytical framework and its expectations give valuable insights into the VANET routing performance in the disengaged network regime [8].
III. PROPOSED WORK

A Vehicular Ad Hoc Network (VANET) is a system where every node represents a vehicle outfitted with wireless communication technology. In a VANET, roadside units (RSUs) are deployed to improve network connectivity, encourage information dissemination, and get to outside systems. In a sparse road scenario, the number of vehicles going through a RSU is small and therefore a RSU does not have a large traffic load in information transmission. For this situation, if a RSU is constantly turned on, it would cause significant energy waste during the period when there is no traffic. To diminish the energy consumption of a RSU and increment the energy efficiency of the framework, it is important to turn off the RSU when there is no requirement for information transmission, and turn the RSU on once information transmission is required. RSU can know the area, direction, and speed of a vehicle when the vehicle enters the radio coverage area of a RSU, which is not generally the situation in this present reality in light of the fact that the scope of a vehicle is usually smaller than that of an RSU. Thus, it is interesting to design an RSU on/off scheduling mechanism.

This on/off scheduling mechanism evaluates the performance metrics like Total Runtime, Load, total Packets Sent, Total Packets Received, Total Packets Dropped, Average Delay, Maximum Delay, Minimum Delay and Energy Efficiency.

IV. TABLES

Table I: Performance Metrics (For 100 Nodes)

<table>
<thead>
<tr>
<th>Range Covered</th>
<th>20 m</th>
<th>40m</th>
<th>50m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Runtime</strong></td>
<td>73.9</td>
<td>74.0</td>
<td>73.5</td>
</tr>
<tr>
<td><strong>Load</strong></td>
<td>0.0063</td>
<td>0.0061</td>
<td>0.0062</td>
</tr>
<tr>
<td><strong>Total Packets Sent</strong></td>
<td>116</td>
<td>112</td>
<td>113</td>
</tr>
<tr>
<td><strong>Total Packets Received</strong></td>
<td>116</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td><strong>Total Packets Dropped</strong></td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Average Delay</strong></td>
<td>0.0153</td>
<td>0.0135</td>
<td>0.0088</td>
</tr>
<tr>
<td><strong>Maximum Delay</strong></td>
<td>0.0803</td>
<td>0.0744</td>
<td>0.0368</td>
</tr>
<tr>
<td><strong>Minimum Delay</strong></td>
<td>0.0019</td>
<td>0.0018</td>
<td>0.0018</td>
</tr>
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</table>

Table II: Performance Metrics (For 150 Nodes)

<table>
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<tr>
<th>Range Covered</th>
<th>20 m</th>
<th>40m</th>
<th>50m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Runtime</strong></td>
<td>73.4</td>
<td>72.8</td>
<td>74.0</td>
</tr>
<tr>
<td><strong>Load</strong></td>
<td>0.0061</td>
<td>0.0064</td>
<td>0.0061</td>
</tr>
<tr>
<td><strong>Total Packets Sent</strong></td>
<td>112</td>
<td>117</td>
<td>113</td>
</tr>
<tr>
<td><strong>Total Packets Received</strong></td>
<td>112</td>
<td>116</td>
<td>112</td>
</tr>
<tr>
<td><strong>Total Packets Dropped</strong></td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Average Delay</strong></td>
<td>0.0152</td>
<td>0.0133</td>
<td>0.0088</td>
</tr>
<tr>
<td><strong>Maximum Delay</strong></td>
<td>0.0710</td>
<td>0.0535</td>
<td>0.0363</td>
</tr>
<tr>
<td><strong>Minimum Delay</strong></td>
<td>0.0019</td>
<td>0.0019</td>
<td>0.0019</td>
</tr>
</tbody>
</table>

Table III: Energy Efficiency

<table>
<thead>
<tr>
<th>Number of Nodes</th>
<th>RSU ON/OFF scheduling OFF</th>
<th>RSU ON/OFF scheduling ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>149.717</td>
<td>118.907</td>
</tr>
<tr>
<td>150</td>
<td>225.545</td>
<td>178.206</td>
</tr>
</tbody>
</table>

V. GRAPHS

Graph I: Energy consumed (in Joules) vs Number of Nodes.
Graph II: Average Delay (For 20m) vs Number of Nodes

Graph III: Maximum Delay (For 40m) vs Number of Nodes

Graph IV: Minimum Delay (For 50m) vs Number of Nodes
The evaluation of energy efficiency of the proposed on/off scheduling mechanism is done based on two scenarios of 100 and 150 nodes. The energy efficiency obtained for 100 nodes when the on/off scheduling is OFF is 149.717 but this value is dropped to 118.907 when on/off scheduling is ON which shows an increase of 20.57% in Energy Efficiency. Similarly, the energy efficiency obtained for 150 nodes when the on/off scheduling is OFF is 225.545 but this value is dropped to 178.206 when on/off scheduling is ON which shows an increase of 20.98% in Energy Efficiency.

REFERENCES
[6] Jing Zhao, Student Member, IEEE, Yang Zhang, Student Member, IEEE, and Guohong Cao, Senior Member, IEEE,” Data Pouring and Buffering on the Road: A New Data Dissemination Paradigm for Vehicular Ad Hoc Networks”, IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 56, NO. 6, NOVEMBER 2007