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Testing of a 3G/LTE Adaptive Information Grouping System in Vehicular Netwroks

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Abstract

The objective of this paper is to develop a vehicular management system using 3g/LTE mechanism.

Vehicular ad hoc networks (VANETs) are a special type of mobile ad hoc networks (MANETs). The special features of VANETs are high-speed vehicular nodes and significant variability in the node density. Gathering data from VANETs is important in observing, regulating, and managing road traffic efficiently. However, effective collection of the required data is challenging because vehicles are continuously moving and create a large amount of events and statistics. The aim of this paper is on acquiring vehicle data using 3G/LTE. First, a comparison of proactive and reactive data collection schemes is made using simulation mechanism. The results show that proactive schemes possess very low delay and bandwidth usage but a very high loss ratio. Therefore for efficiently using the useful bandwidth, a new additive data collection scheme is generated. This data collection scheme is based on a proactive scheme using variable polling periods which depend on the position of the vehicle in the network and travel time to give correct data of the traffic and travel time to the Traffic Center (TMC). Simulation results, using the taxi traces in Qatar, signify that the algorithm utilizes a favorable amount of megabytes (≈31 MB) per month when the essential polling interval is set to basic 10 s. Further, traffic simulation results show that the suggested method has a lesser affect on delay and travel time estimates (relative error less than 2.5%), but they can generate large degradations in fuel consumption and emission estimates if computations are done at the TMC (relative error greater than 28% and 65%, respectively). These errors can be removed if computations are done on the vehicle itself.

Index Terms: Mobile communication, data collection, automotive applications, intelligent transportation systems, wireless networks, traffic information, data aggregation, travel time estimation, vehicle emission estimates.

1 .INTRODUCTION

Vehicular specific networks (VANETs) share lot of similarities with Mobile specific networks (MANETs) like the features of node movement, ad hoc operation and self-organization. But the features that distinguish VANETs from MANETs are the extremely dynamic configuration that changes swiftly and regularly and better node density. This can be principally owing to the upper speeds of transport nodes and variable node density. A variety of efforts are created on the techniques of data collection techniques so that the inter-vehicle communication is systematic and dependable while minimizing bandwidth utilization. Most VANET applications depend on the dispersion process [1]–[5] for which data must be communicated over a long distance so that drivers can be alerted beforehand. As each vehicle in a vehicular network can detect a dangerous situation or a congestion zone, the amount of messages sent along the network might increase significantly. Hence, the technique of gathering information Packets from moving vehicles and accumulating the vehicle beacons, is considered a very significant method to avoid these problems.

The prominence of V2X (Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I)) networks lends essential support for Intelligent Transportation Systems (ITS) to boost several applications for various purposes like safety, traffic regulation and other value added services. Typically, such an environment is characterized by its flexibility and topology over space and time. Enabling such applications requires the vehicles to periodically broadcast beacons every 100 ms which contains the information about the position and speed of the vehicle [6], [7]. To permit the analysis of traffic data, the best method is to gather these beacons from the vehicular network through 3G/LTE or Road Side Units (RSUs) using 802.11p at a centralized Traffic Management Center (TMC). Consequently, the TMC can perform analysis of traffic data to typify the traffic patterns and spot incidents in order to take some actions such as regulating traffic lights, inform police or provide traffic data to drivers through Radio Data System-Traffic Message Channel (RDS-TMC) or Transport Protocol Experts Group (TPEG) standards [8].

The Mobility Innovations Center of Qatar (QMIC) has a mobile application, named iTraffic [9], that provides the status of current traffic and navigation information to drivers in Qatar. The system uses probe data collected from 200 devices deployed along the Qatar road network. As a result, the system signifies the importance of collecting data from the application users to cover all the zones and minimizing the time and data consumed by the application from the user data plan.

Hence this paper focuses on vehicular data collection through 3G/LTE technology enabled in either a Smartphone application or a component embedded in the car which can send its data to the TMC. The basic principles from this work can be summarized as follows. Firstly, we compare the proactive and reactive approaches of data gathering using LTE technology. Then, we develop an adaptive data collection system (ADCS) [10] to gather information so that the bandwidth is utilized efficiently. Then, the protocol performance using bandwidth and saving was examined using real taxi traces. Finally, the algorithm was tested in a simulation surrounding to measure the affect of the data aggregation on the estimates of various measures of effectiveness (MOEs). Our idea deals with non-variable delay and minimizes bandwidth consumption for emergency traffic situations (dangerous situation, congestion zone, etc). The principle concept of the ADCS mechanism is to provide a location aware adaptional data collection protocol .The results show that the proposed scheme minimizes the amount of data sent though the network while not negatively affecting the performance of travel time prediction applications predicting travel times.

2. EXISTING SYSTEM

There are two ways in which information can be collected, proactive and reactive data collection approaches. Proactive data collection is considered when vehicles are supposed to report their criterion such as speed, direction, position, fuel usage, etc.) Every period p to the TMC. In current V2X standards, a vehicle broadcasts a beacon message periodically every 100 ms. the reactive data collection is used when TMC requests, either periodically or when required, all or few chosen vehicles to provide their instantaneous parameters or a historical report. The total number of messages in a reactive scheme is greater. The Proactive approach suffers from a higher loss ratio, because of message collisions between vehicles sending data at the same time. However the reactive data collection scheme uses sequential requests thus reducing the chance of collisions. The E-MBMS, the Evolved Multicast Broadcast Multimedia Services, can be used to broadcast or multicast requests to vehicles so as to cut the total messages in the network, but losses will be greater as several vehicles respond at the same time. In addition, the number of bytes in user data will remain same.

3. PROPOSED DATA COLLECTION SYSTEM

3.1 Network model

The communication network is principally composed of vehicles and a TMC. Vehicles are provided with a mechanism that can read its parameters and share them with the TMC using only 3G/LTE communication technologies. In other words, they can share with TMC through the Internet. We suppose that the road network is split into macro-segments, that are segments between road junctions. This road map is saved in vehicles. A speed estimate related to each macro-segment allows the calculation of a base uncongested travel time. In addition, vehicles can run the function *FindCurrentMS*() to find their current macro-segment using their GPS coordinates.

3.2 Proposed Model

The basic idea is to have two dynamic timers and a condition to pick the sending frequency of data towards the TMC. The first timer *I*max defines the time difference between two successive messages. It is chosen by the TMC and can be updated as required. This value can differ depending on vehicles in different zones. Thus it can be reduced when and where more data is needed and increased when and where there is a sufficient penetration rate or many sources are in a specific area. The second timer is activated when the travel time of a vehicle along a path crosses the maximum estimated travel time (*e*max). Thus facilitating the TMC to update the *e*max based on the vehicle's position helping it to know about the distances travelled and remained. The condition checks if the current macro-segment is different from the last seen one

3.3 Proposed Data Collection Model

We consider a network of vehicles that periodically samples local measurements (e.g., position, speed, etc.) at an adaptive rate that is dynamically updated by the TMC. The adaptive data collection algorithm can be described as two distributed processes running in the TMC and the vehicles.

3.3.1 Process at TMC: The TMC collects data from all the

Connected vehicles in order to compute the estimated travel

time using real-time and historical data. The algorithm used to compute the estimated travel time is beyond the scope of this paper but has been developed in numerous research papers. The TMC can detect congestion, road derivation and new segments .Vehicles can request the routing information from the TMC along with the mean and maximum estimated travel time, e and $e$max, respectively.

The vehicle can also request the data from nearby segments when not using TMC. This information is required to run the adaptive data collection algorithm

3.3.2 Process in Vehicle: The vehicle tries to update traffic and road status information by collecting and sending the required data to the TMC. Therefore, sending a beacon every 100 ms exhausts the user's data plan. A better approach is to use adaptive data collection algorithm, shown in Fig.1 to regulate and reduce the amount of data sent to the TMC.

3.3.3 Algorithm: The algorithm starts when the vehicle is ON and the GPS signal is available. Subsequently, it initializes some required variables: *once* to *False* and *Sc* to the current macro-segment. Next, it evaluates the expression:($ct - L > I\max \vee S \_= Sc \vee (Tt > e\max \wedge once = False)$)(1) which is used to check if the last message to the TMC was sent before Imax, or the current segment is different from the last saved one, or the travel time has exceeded the maximum estimated travel time. If all the conditions are false, the vehicle waits for *Ip*, the interval period between two successive checks which may be set to 100 ms by default. Then, the vehicle obtains its current parameters (e.g., position, speed, heading, etc.) using the function *GetCurrentParams*(). Next, it attempts to find the current macro-segment (MS) through the function *FindCurrentMS*(). This function may give a *NULL* value if its not able to relate a MS to the current position, which may mean that the GPS signal is lost. Thus, values are stored and the algorithm continues to work till it finds a MS. Subsequently, if the function *FindCurrentMS*() relates a MS with the vehicle GPS coordinates, the algorithm returns to check Eq. (1).If the new segment *Sc* is different from the previous one *S*, it is saved, *once* is changed to *False* and the current value of time *ct* is stored in *L*, the Last sent message time. Further, a message is sent towards the TMC. The message contains: the previous and current MS, the travel time along the segment, *ct*. If the maximum period Imax between two messages is exceeded, a message is sent to the TMC. If the current travel time exceeds $e$max and *once* is *False* showing that no messages have been sent to inform the TMC about this timeout.

4. MODULES

4.1 Communication Module
4.2 Vehicle monitoring module
4.3 ADCS module

4.1 Communication Module: Initially in VANET all the vehicles communicate through a type of Vehicle to Vehicle communication. Supply node send RREQ to all or any of the neighbors, once destination node receive the RREQ it'll send RREP to supply. Then it'll update the routing table. It forwards the info within the same route.

4.2 Vehicle monitoring module: VANET, all the vehicles have GPS for locating the situation of the vehicle. Drivers can precisely recognize their location. GPS facilitates the navigation. However, in several things, the GPS receivers lose satellite signals and calculate wrong positions as a result of signal interference, reflection and interference. For an example, it's quite possible that the GPS handsets report wrong data once they are measured in crowded metropolitan space, like Manhattan, where there are several tall buildings. The GPS receivers conjointly lose satellite connections in places like tunnels or multi-floor bridges, leading to safety and convenience drawback.

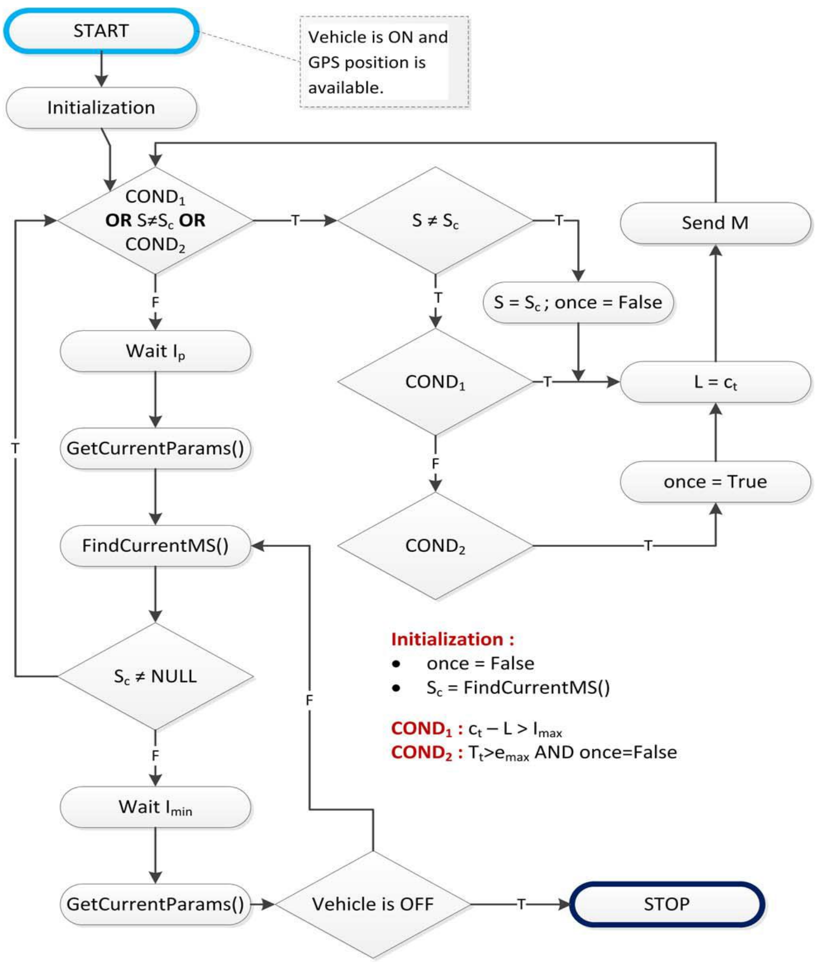


Fig 1. Adaptive data collection approach

4.3 ADCS

In this scheme, vehicles in a network organize themselves in a vehicular network and exchange location associated distance data and facilitate one another to calculate a correct position for all the vechiles in the network . A vehicle obtains Location, speed, heading, fuel consumption and distance data and communicate it to TMC. The messages are going to be broadcast at the rate of 100ms each.This approach discovers congestion, road derivation and new segments.

5. PROJECT REQUIREMENTS

5.1 Hardware:

Single PC

20 Gb Hard disc space

1 Gb RAM

5.2 Software:

Linux OS (Ubuntu 10.04)

NS2.34

6. OUTPUT

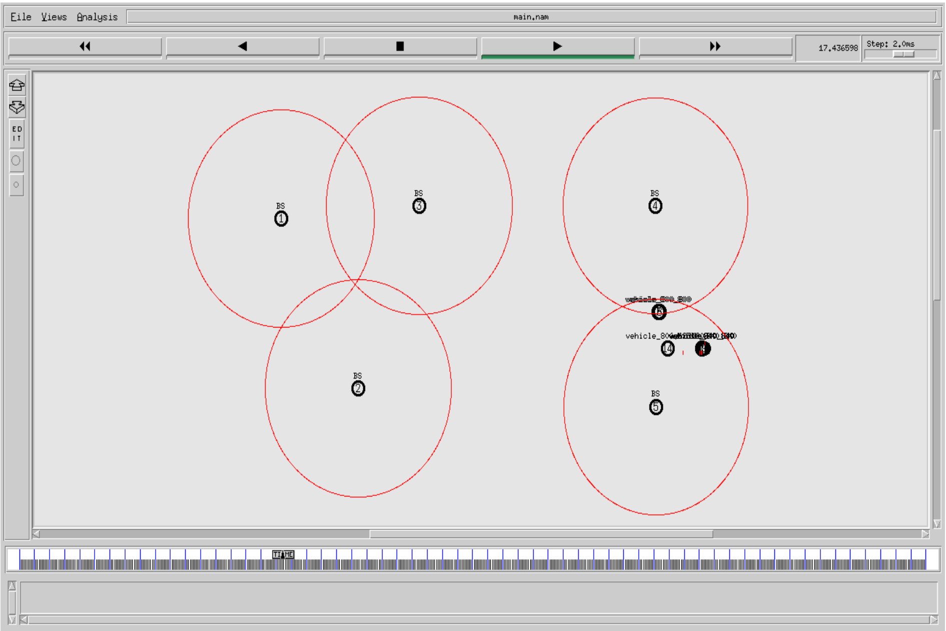
While the adaptive data collection can effectively gather speed and delay information of the vehicle, the correctness of fuel usage and emissions is greatly affected. The following figures show the graphic representation of simulation results. The results show that increasing Imax reduces the amount of data sent by the vehicles. Depending on the Imax, the algorithm can lessen the amount of data sent by each vehicle.

Output 1 shows the NAM window

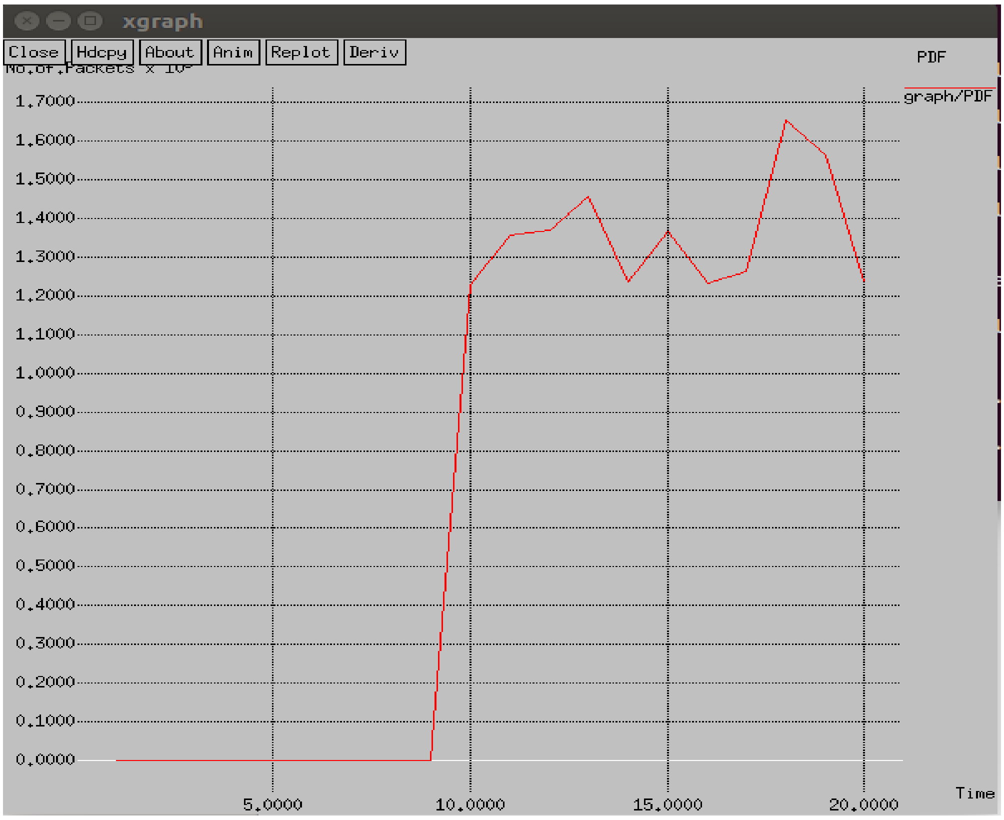
Output 2 shows the packet delivery factor vs time

Output 3 shows the Overhead with respect to time

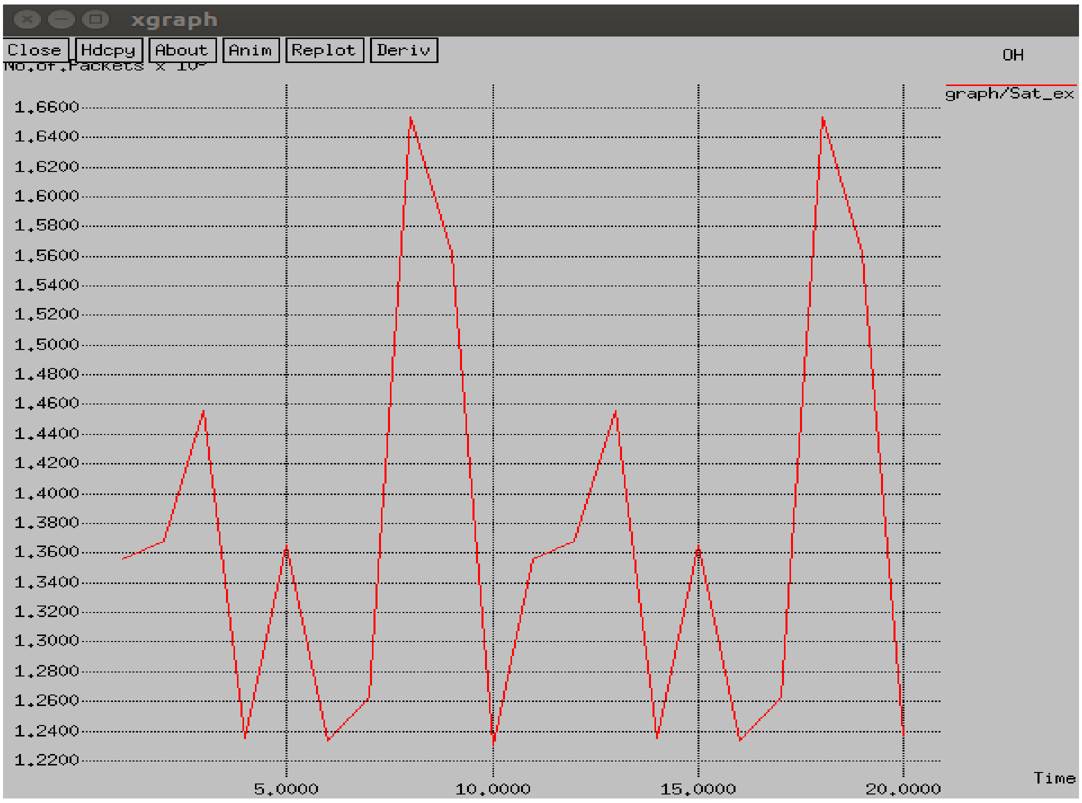
6.1 Output 1



6.2 Output 2



6.3 Output 3



7. CONCLUSION

The paper presented a comparison between proactive and reactive data collection mechanisms. Subsequently, the data collection is done using the adaptive algorithm using the 3g/LTE communication network. Further, the validation process is done using in-field taxi data to assess the performance of the system in terms of bandwidth savings. Finally, the algorithm was tested in a simulation environment to measure the affect of the data grouping on the estimates of various effective measures. The results show that computations done using 10 s data has the least impact on delay estimates (error less than 2.5 percent) and travel time estimates (error less than 18 percent), however, it has a great affect on vehicle fuel consumption and emission estimates (over 38 and 65 percent error, respectively). A solution to this issue would be for an available system to group the data and then send the estimates to the TMC at the polling intervals. This is to make sure that the estimates are not deteriorated for different levels of resolution. The results are promoting further testing of the algorithm in real world devices and comparing the travel time estimates at the TMC based to the ground truth.

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