Efficient Data Transmission with Priority in Heterogeneous Networks

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ABSTRACT

In wireless networking domain, diverse wireless technologies are utilized for sharing data and providing data services. The protocols used in VANETs are DYMO and AODV+. Both of them can provide internet by communicating with Road Side Units (RSUs) which are static. This application has performed well, still leaving some challenges for the designers to be met in advancements. In this work, a novel architecture 3G/UMTS networks are integrated with VANET networks in which a minimum number of gateways, per time instance are selected to connect ordinary vehicles with the UMTS network.

In the proposed architecture, AODV is used in forming a VANET and a radio link to connect a VANET to 3G/UMTS base station through a gateway. There is an instance, where a node must be given priority. The gateway must give highest priority in serving priority needed node by broadcasting about the arrival of vehicle and requesting the remaining nodes in a VANET to clear the road for a while. Simulation is carried out for priority node and priority-less node and better results are obtained.

Index Terms--VANET, 3G, UMTS, AODV, AODV+, DYMO, RSU.

I. INTRODUCTION

In today's wireless networking domain, diverse wireless technologies are utilized for sharing data and providing data services. Among the available technologies, the leading examples are the widely-deployed 3G cellular networks and IEEE 802.11-based Vehicular Ad hoc Networks (VANETs). 3G cellular networks, such as Universal Mobile Telecommunication Systems (UMTS), are pre-dominantly used for wide-area wireless data and Node B. On the other hand, VANETs are used for shortrange, high-speed communication among nearby
vehicles, and between vehicles and roadside infrastructure units [1]. voice services via access to a Base Station Transceiver (BST), also referred to as UMTS Vehicle-to-Vehicle (V2V) communication supports services such as car collision avoidance and road safety by exchanging warning messages across vehicles [5].Internetworking over VANETs has been gaining a great deal of momentum over the past few years. Its increasing importance has been recognized by major car manufacturers, governmental organizations and the academic community. The Federal Communications Commission has allocated spectrum for Inter-Vehicle Communications (IVC) and similar applications (e.g., wireless access in vehicle environment).

In this paper, the enhanced version of IEEE 802.11networks, which is IEEE 802.11p, forms the standards for Wireless Access for Vehicular Environments (WAVE). It operates at a frequency of 5.9 GHz, divided into 7 channels, each operating at a frequency of 10 MHz. It provides a high data rate, ranging from 6 Mbps to 27 Mbps and a shortrange radio communication of approximately 300 meters.

By integrating VANET with UMTS, high data rate can be coupled with wide-range of communication. In the envisioned VANET/3G network, if one vehicle is connected to the UMTS network using its 3G UTRAN interface, it can serve as a relay node (i.e., mobile gateway) for other vehicles in its vicinity to access the UMTS network, by receiving data from them (using its IEEE 802.11p interface) and relaying the data to the UMTS network. With such an integration, dead spots in UMTS can be minimized to a significant extent.

II. REVIEW OF EXISTING SYTEMS

As already given in the abstract three important protocols are used in forming a VANET. They are DYMO, AODV+ and AODV. Let's see a brief discussion about the three protocols.

A. DYMO (Dynamic MANET On demand routing protocol)

The Dynamic MANET On-demand routing protocol (DYMO) is a newly proposed protocol currently defined in an IETF Internet-Draft [9] in its twenty-first revision and is still work in progress. DYMO is a successor of the AODV routing protocol. It operates similarly to AODV. DYMO does not add extra features or extend the AODV protocol, but rather simplifies it, while retaining the basic mode of operation. As is the case with all reactive ad hoc routing protocols, DYMO consists of two protocol operations: route discovery and route maintenance. Routes are discovered on demand when a node needs to send a packet to a destination currently not in its routing table. A route request message is flooded in the network using broadcast and if the packet reaches its destination, a reply message is sent back containing the discovered, accumulated path. Each entry in the routing table consists of the following fields: Destination Address, Sequence Number, Hop Count, Next Hop Address, Next Hop Interface, Is Gateway, Prefix, Valid Timeout, and Delete Timeout.

B. AODV (Ad Hoc On-Demand Distance-Vector Routing Protocol)

The AODV Routing Protocol [8] provides on-demand route discovery in mobile ad hoc networks. Like most reactive routing protocols, route finding is based on a route discovery cycle involving a broadcast network search and a uni-cast reply containing discovered paths. AODV relies on per-node sequence numbers for loop freedom and for ensuring selection of the most recent routing path. AODV nodes maintain a route table in which next-hop routing information for destination nodes is stored. Each routing table entry has an associated lifetime value. If a route is not utilized within the lifetime period, the route is expired otherwise, each time the route is used, the lifetime period is updated so that the route is not prematurely deleted.

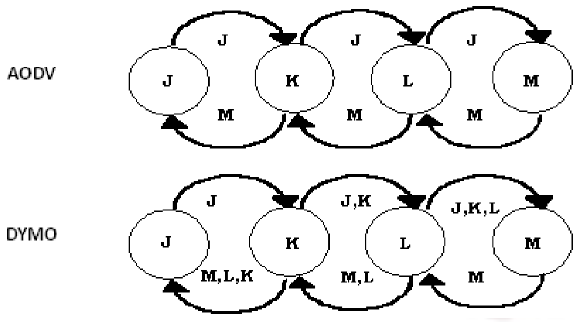


Figure 1: path establishment in AODV and DYMO

C. AODV+ Protocol

AODV is modified to support mobile devices in network to communicate with fixed devices in Internet. This modified addition if AODV is known as AODV+. For the Internet access AODV+ has to discovery gateway. This gateway discovery is classified into three types: Pro-active gateway discovery, Reactive gateway discovery and Hybrid gateway discovery. In pro-active gateway discovery, gateway periodically broadcast a gateway advertisement (GWADV)message to all the mobile nodes. The mobile node that receives the advertisement creates a route entry for the gateway and then sends the acknowledgment back to gateway. To avoid duplication of advertisement GWADV ID Field is used with message .In reactive gateway discovery process is initiated by mobile nodes. This mobile node broadcast RREQ message to all nearby gateway. Intermediate mobile nodes are not allowed to process RREQ message. When RREQ message is received by gateway it uni-casts the RREP to mobile nodes.

III. Clustering based Multi-metric mobile Gateway Management mechanism

The proposed priority concept can be understood from the following figure.

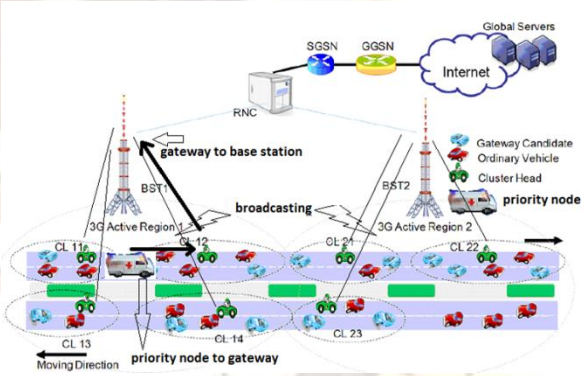


Figure 2: Proposed Architecture

CMGM protocol works depending on three main metrics for clustering and two algorithms for gateway management. The three metrics are:

a. Direction of Movement
b. UMTS Signal Strength
c. IEEE 802.11p wireless transmission range.

A. Multi-metric Mobile Gateway Selection Mechanism (algorithm 1)

It is employed upon the available CHs of the GWC sub-cluster. The algorithm is based on the Simple Additive Weighting (SAW) technique. The considered metrics of the CH are the mobility speed, the UMTS RSS, and the link stability. The link stability is defined by the LET and RET metrics between the source and the CH. At a certain time instance, let (xi, yi, zi) and (xj, yj, zj) denote the Cartesian coordinates of two neighboring vehicles i and j, moving at speeds vi and vj , along two roads inclined at θi and θj $(0 < \theta i, \theta j < 2\pi)$ with respect to the x-axis, respectively. Let R denote the maximum wireless transmission range of the IEEE 802.11p interface of the two vehicles. $LETij$ can be then computed as in Equation (5).

$$LET_{ij} = \frac{-(ab+cd)+\sqrt{(a^2+c^2)R^2-(ad-bc)^2}}{a^2+c^2}$$

where,

$a = v_i cos\theta_i - v_j cos\theta_j$; $b = x_i - x_j$

$c = v_i sin\theta_i - v_j sin\theta_j$; $d = y_i - y_j$

Intuitively the larger the value of the LET, the higher is the stability of the link. Let a route between a source and the gateway consist of (n - 1) links between n vehicles. RET of the route can be then expressed as follows:

$RETn-1 = min\{LETi,i+1\}, i = 1...n - 1$

The scaling, weighting of priority factors and normalization of the metric values follow the method described to obtain the scaled metric value *Yi* and weight (*WCH*) of any *CHi*. In Algorithm 1, the UMTS RSS and RET are metrics with positive criterion (i.e., more optimality with increase in value). As far as the mobility speed metric is concerned, if the direction of movement is towards the BST, the criterion is positive whereas if the movement is away from the BST, the criterion is negative (i.e., less optimality with increase in value). However, in this paper, the first vehicular source broadcasts a Gateway Solicitation (GWSOL) message within the VANET, using the TTL value as discussed in Section V-C. Given the fact that a hybrid gateway discovery mechanism is employed, every GWC belonging to a cluster knows information about its CH. Hence, it is sufficient for the GWSOL to reach any GWC of a cluster to get information about its CH; instead of reaching directly the CH. The metric information of each CH lies with the GWCs of the cluster. When the GWSOL message reaches any GWC, this information is notified to the source. An optimal gateway is then selected by the source vehicle using the MMGSA mechanism. The source vehicle then notifies the vehicles of the newly selected gateway. By the time the next set of vehicular sources emerge, at least one gateway would have been elected as a result of the GWSOL initiated by the first source.

Each metric of the CH has its own threshold value. After a time interval _t, if another vehicle becomes an active source for communicating with the UMTS BST, that source checks if the UMTS RSS of the serving gateway and its RET with the gateway are greater than the respective threshold values SS_{Th} and RET_{Th}. If yes, the active source uses the same gateway for communicating with the UMTS BST. Otherwise, the source selects another gateway from the remaining CHs of the other clusters, by applying the MMGSA approach. Thus, MMGSA selects only a minimum number of optimal gateways, saves the UTRAN access network resources, especially during handoff, by letting only a minimum number of gateways communicate with the UMTS BST at an instance. It should be noted that, according to the above discussed multi-metric gateway selection algorithm, the RET value is the maximum for a source with its nearest CH. This is because if there exists any sub-cluster beyond the reachable sub-clusters from the vehicular source, the RET between the source and the CH of that sub-cluster will be null as there will be no common neighbor GWC between any two sub-clusters.

B. Multi-metric Adaptive Mobile Gateway Handover Mechanism(algorithm 2)

The pseudo-code of the gateway handover mechanism is shown in Algorithm 2. The main concept behind the gateway handover approach is as follows. If the UMTS RSS of the gateway goes below the signal strength threshold and/or if the RET of the gateway with the source vehicle goes below its predetermined threshold, migration from the serving gateway to one or more gateways, selected by MMGSA, should take place for that vehicle. It should be stated that the mobility speed metric is not considered in the gateway handover decision due to the extremely inconsistent and dynamic variation in the velocity of vehicles, which makes it difficult to use a threshold value for speed. The serving gateway forms a list of Gateway-Elects by selecting one or more CHs having the maximum weight with respect to each of its sources. All new incoming transactions are forwarded to the new Gateway- Elects. The serving gateway GW informs the current active vehicular sources in VANET about the Gateway-Elects using a hybrid gateway discovery and advertisement mechanism.

During the gateway selection, the gateway may correspond with one of the CHs. However, at a different instance, the same gateway may not serve as a CH, due to the dynamic clustering mechanism, stated above. It may also instantaneously lose all its neighbors which it had while being elected. It subsequently forms or joins a new cluster, while still maintaining its role as gateway in case its optimality is not affected, and gets new neighbors during the communication course. There is also no guarantee that it will be the CH of the new cluster. Prior to losing its optimality, a serving gateway selects Gateway-Elects (one or more), with respect to each of its active sources.

Additionally CMGM also performs gateway advertisement at the time of handover, determines cluster head and also TTL(Time-To-Live)of a cluster.

IV. PRIORITY IN HETEROGENEOUS NETWORKS

In priority resolving, the operation is carried in three phases. They are:

a) Identification of vehicle,
b) Gateway resolving its priorities
c) Serving vehicle by broadcasting its arrival.

In the normal environment the gateway serves all its nodes equally without any priority. There is an instance where a vehicle has to be given priority. In the process of giving priority, first vehicle is identified by the gateway. For the gateway to identify vehicle, vehicle is given fixed IP address irrespective to the location and care is taken such that normal nodes will not have the same IP address. Then gateway receives the request packets from the vehicle with IP address given to it.

On receiving request packets from vehicle the gateway has to check its table of IP addresses, which it is serving now. Then it uses priority resolving method which is static, in allocating priority to vehicle IP address. This kind of priority method is known as fixed priority method.

Actually gateway acts as a Wi-Fi access point. So it can serve all the nodes at a time. But the drawback is delay. Because gateway has to transmit the information to all its nodes at the same time. This causes communication delay and results in traffic jam journey for vehicle. This is solved by giving priority to information coming from node in need of priority. Hence the information from priority node is sent to base station for broadcasting purpose by the gateway prior to the information coming from remaining nodes[6].

Parameters	Value
Area	8000 x 1000(m^2)
Channel	Channel/ Wireless channel
Propagation Model	Propagation/nakagami
Network Interface	Phy/WirelessPhyExt
MAC Interface	Mac/802_11Ext
Peak Wireless Transmission Range	300m
Interface Queue Type	Queue/DropTail/PriQueue
Interface Queue length	20 packets
Antenna Type	Antenna/OmniAntenna
Routing Protocol	AODV
Total number of VANET vehicles	11
Peak Mobility speed	30ms^{-1}
Mobility Model	Manhattan Mobility Model
UMTS RSS Threshold	-94dBM
Transport-Layer protocol	TCP/Newreno
Application	FTP
Packet size	1 KB

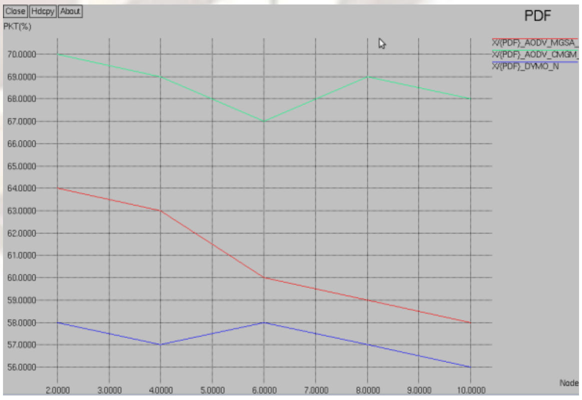
Table 1: NS2 simulation parameters for VANET

Parameters	Value
Uplink Frequency	1.95GHz
Downlink Frequency	2.115GHz
Peak UTRAN Uplink Channel Bit Rate	384 Kbps
Peak UTRAN Downlink Channel Bit Rate	2 Mbps
Transmission Range of UMTS Node B	7 km
Node B Interface Queue length	20 packets
UMTS Node B – RNC Data Rate	622 Mbps(Transmission Time Interval (TTI): 1 ms)
RNC – SGSN Data Rate	622 Mbps(TTI: 1 ms)
SGSN – GGSN Data Rate	622 Mbps(TTI: 10 ms)
GGSN – External IP network data rate	10 Mbps (TTI: 15 ms)
Routing Protocol	3G Pro-active routing

Table 2: NS2 simulation parameters for UMTS

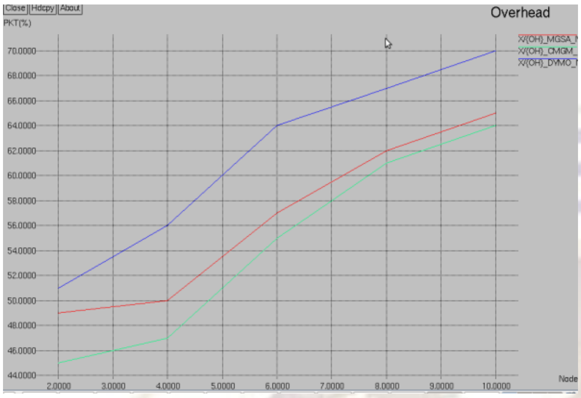
V. SIMULATION RESULTS

The proposed Grouping-based Poly-functional mobile Gateway Management mechanism (CMGM) is implemented in the Network Simulator NS2.34. For creating a mobile terminal with dual interfaces, the IEEE 802.11 and the UMTS libraries of NS-Miracle were used. The scenario consists of a VEHICLE GROUP connected to the 3G network via the UTRAN interface. Tables I and II list the simulation parameters of the VEHICLE GROUP and 3G network s, respectively. The performance of the integrated network is evaluated in terms of Data Packet Delivery Function, Control Packet Overhead, throughput. The simulated results are given below:



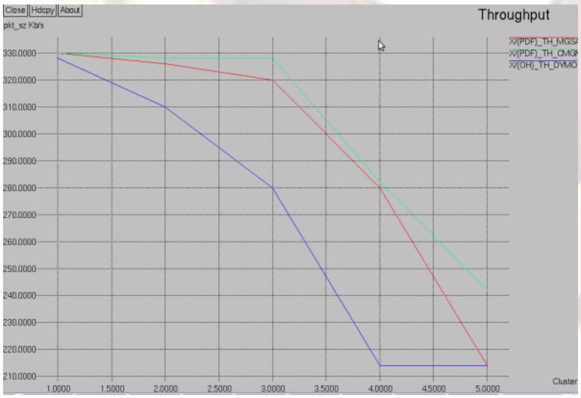
Graph 1: data packet delivery ratio versus number of nodes

The graph 1, demonstrates the good performance of the proposed CMGM in terms of higher DPDR, compared to the other two protocols, and that is for different numbers of vehicular sources in the VANET. The graph indicates that regardless of the underlying protocol, DPDR generally tends to decrease along with increase in the number of sources. The curves show a negative trend. Indeed, the number of sources increases, the packet drops subsequently increase, especially when the gateway is on the verge of losing its optimality.



Graph 2: overhead versus number of nodes

The above graph 2 shows increase in CPO against the number of sources generating data. Though this is generally the trend, CMGM over AODV shows less CPO compared to the other protocols. This is due to the fact that only minimum numbers of adequate gateways are elected for carrying on the transaction, which significantly reduces CPO due to multiple gateways, as in the case of MGSA. However, a small amount of overhead is involved during handover. One of the main differences between MGSA and our proposed CMGM mechanisms consists in the fact that mobility is considered as a highly important metric in CMGM whilst it is overlooked in MGSA.

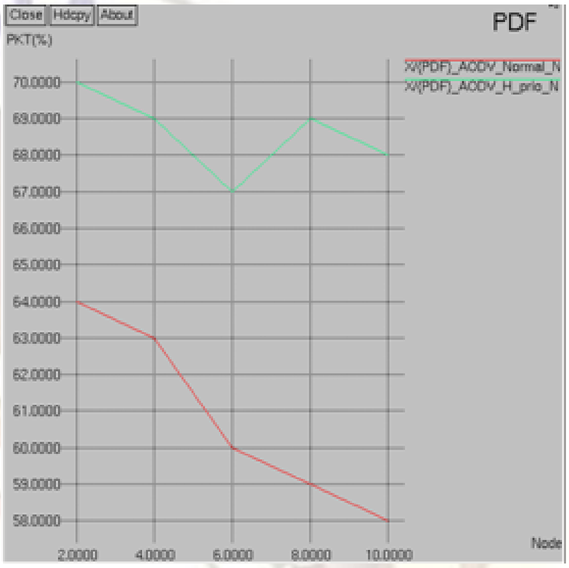


Graph 3: throughput versus number of clusters

In this graph, the achieved average individual throughput by using three different protocols is plotted for different numbers of clusters.

In case there are many VANET clusters, CMGM would be able to select optimal CHs as gateways and to support service continuity. However, in case there are few clusters with not enough available gateways (i.e., less than the required optimal number), the selected gateways will be overloaded with data packets; some of which will be discarded, ultimately impacting the throughput. Hence, the first set of readings in the figure does not show a big difference in the throughput achieved by the three protocols.

The simulation is carried out by giving priority to vehicle and the graph is plotted for the data packet delivery ratio versus the number of nodes, for priority node and a node without priority then the graph resulted as follows:



Graph 4: data packet delivery ratio versus number of nodes for priority and priority-less vehicles.

VI. CONCLUSION

In this paper, we describe a network architecture that integrates VANET with UMTS and WIMAX. To enable such an integrated architecture, vehicles are clustered according to different metrics. A minimum number of adequate vehicles are selected to connect VANET and UMTS. Gateway management and selection is also performed in a dynamic manner using different metrics and in any emergency situation emergency nodes must be given priority such that they can be driven obstacle-free by broadcasting the messages within inter-VANET and intra-VANET. Hence this application can help vehicle to reach the place in-time. The result of data packet delivery ratio for priority and priority-less vehicles is presented in the paper. So in future work, we will present the simulation results for overhead and throughput also.

VII. REFERENCES

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