Vehicular Communications ••• (••••) •••–•••

Contents lists available at ScienceDirect

Vehicular Communications

www.elsevier.com/locate/vehcom

Quality of service aware multicasting in heterogeneous vehicular networks

Mehdi Sharifi Rayeni, Abdelhakim Hafid, Pratap Kumar Sahu

Department of Computer Science and Operations Research, University of Montreal, Montreal, Canada

ARTICLE INFO

Article history:
Received 17 November 2017
Received in revised form 5 March 2018
Accepted 10 April 2018
Available online xxxx

Keywords:
Intelligent transportation systems
Vehicle-to-vehicle/roadside/Internet communication
Communication architecture
Heterogeneous vehicular networks
Multicasting
Steiner tree

ABSTRACT

Heterogeneous Vehicular Networks (HetVNets) provide great potential for on-demand services. Such services require real-time request-reply routing between vehicles as clients and service providers as the source. One naïve solution to deliver service is unicasting between service provider and each client. Unicasting consumes considerable bandwidth, since service provider requires establishing a separate communication path to each client. In contrast, the service provider can construct a multicast tree to simultaneously transmit multicast packets to all clients. We propose two approaches to model total bandwidth usage of a multicast tree: (1) Min Steiner Tree that considers the number of street segments involved in the multicast tree; and (2) Min Relay Intersections Tree that considers the number of intersections involved in the multicast tree. We propose a heuristic that incorporates the first approach to minimize delay of the multicast tree. We propose another heuristic that uses the second approach to minimize the number of relay intersections in the multicast tree. Extensive simulations show that the proposed approaches outperform existing contributions in terms of number of transmissions, delivery delay, packet delivery ratio, and overhead. We also show that the proposed approaches near-optimally minimize bandwidth usage while ensuring QoS (i.e. network connectivity and packet transmission delay).
© 2018 Elsevier Inc. All rights reserved.

1. Introduction and motivation

Vehicular Ad hoc Networks (VANETs) are envisaged to be one of the building blocks for future Intelligent Transportation Systems (ITS). Initial design objective of researchers and practitioners for VANETs was to provide drivers awareness about road safety and traffic conditions. However, this objective has been expanded to include Internet access services on road, multimedia upload/downloads, road toll payments, on-road advertisements, and other commercial/entertainment services. Future Intelligent Transportation Systems (ITS) will enable vehicles to send and receive data about traffic and road safety situations, along with information services which provide data about available infotainment services on streets. VANETs allow vehicle-to-vehicle (V2V) communications between vehicles and vehicle-to-infrastructure (V2I) communications between vehicles and Road Side Units (RSUs). The main features of VANETs include high velocity nodes (i.e. vehicles), dynamic topology and restricted mobility patterns of nodes. DSRC (Dedicated Short Range Communication) technology, which operates on 5.9 GHz, enables vehicle ad hoc communications and has led to development of standards, such as IEEE 802.11p to add Wireless Access in Vehicular Networks (i.e. WAVE) and IEEE 1609.x family of standards [1–3]. However, V2V communications suffer from scalability issues, e.g. limited radio coverage, lack of pervasive communication infrastructure, and unbounded delay in case of increasing number of vehicles [30]. The same issues apply to V2I if DSRC is the only technology used for communications. Hence, a pervasive access technology is inevitable to support the ever-increasing vehicular applications in VANETs. The fourth generation (4G) Long Term Evolution (LTE) is nowadays considered as a promising broadband wireless access technology that provides high uplink and downlink data rates with low latency. Thus, car manufactures are going to enhance cars with both short range DSRC and long range LTE and LTE-Advanced (LTE-A) equipment [31,32,35]. The resulting heterogeneous communication network consists of (i) WAVE standard for V2V and V2I communications (i.e. VANETs), and (ii) LTE technology for vehicle and RSU communications to evolved NodeB (eNodeB) Radio Access Network units (E-UTRAN). Hence, vehicles have two communication options: WAVE and LTE networks. Vehicles may hand off between their WAVE- and LTE-enabled interfaces. We refer to the resulting network as Heterogeneous Vehicular Network (HetVNet) [37,38]. However, it is too optimistic to assume that all vehicles in near future will be equipped by both WAVE and LTE interfaces. Indeed, there will be considerable cost involved to install them both (plus additional

E-mail address: sharifim@iro.umontreal.ca (M.S. Rayeni).

https://doi.org/10.1016/j.vehcom.2018.04.002
2214-2096/© 2018 Elsevier Inc. All rights reserved.

Please cite this article in press as: M.S. Rayeni et al., Quality of service aware multicasting in heterogeneous vehicular networks, Veh. Commun. (2018), https://doi.org/10.1016/j.vehcom.2018.04.002

monthly charges for LTE service); moreover, other factors are involved, such as the time it will take (a) to find a consensus among industry players (e.g. cellular vendors and car manufacturers); and (b) to legislate for DSRC+LTE communication devices for traffic safety. Hence, in this paper, we consider a generic type of HetVNet in which vehicles are divided into three main groups: (a) vehicle has both WAVE and LTE interfaces, (b) vehicle has neither WAVE nor LTE interfaces, (c) vehicle has either WAVE or LTE interfaces. Despite recent research in heterogeneous vehicular networks, it is still an open issue to provide network services for vehicles with the partially-enabled interfaces [31,37]. Even if a vehicle has both interfaces, it might not be able to use them simultaneously, as one of the interfaces would have been waiting for the next available slot to communicate in high channel congestion scenario [39,40].

Data exchanged in HetVNet may be categorized into (i) safety-related data: it includes periodic beacon messages and emergency warning messages (e.g., accident warning); and (ii) non-safety data: it includes a vast area of multimedia and infotainment communications, such as vendor advertisements and vehicle services on the road and parking information. Beacon messages include status information about location, velocity, acceleration and direction that each vehicle broadcasts periodically to update neighboring vehicles about its state. Emergency messages are broadcasted by a source vehicle when an emergency situation occurs (e.g., hard brake, chained collision or head-on collision) to alert other vehicles about the event. In this paper, we consider the on-demand infotainment communication services and the mechanisms to deliver messages to the WAVE-only enabled vehicles which we call *clients*. The services are provided to clients through the conjunction of LTE and WAVE ad hoc networks (see Fig. 1). The WAVE mode is used for multi-hop communications from RSUs to the clients. In our proposed architecture, we assume that RSUs have WAVE interfaces and are connected to the internet (e.g., via wireline or wireless links). A client that is interested in a service sends its request via WAVE multi-hop path towards the closest RSU; along the path to RSU, there may exist a vehicle with both LTE and WAVE interfaces (see step 1 in Fig. 1(a)). If it is the case, the vehicle then forwards the request to the corresponding Cloud service in Cloud Center (see step 2 (vehicle to eNodeB) and step 3 (eNodeB to Cloud Center) in Fig. 1(a)); Cloud service will respond and forwards the reply via the closest RSU to the client (see step 1 (Cloud Center to RSU), step 2 (RSU to a vehicle in its range), and step 3 (from the vehicle to the client) in Fig. 1(b)); For the response path in Fig. 1(b), we use the closest RSU instead of the WAVE and LTE-enabled vehicle of Fig. 1(a); that is because the WAVE and LTE-enabled vehicle may have changed its position by the time the reply message is prepared and sent by Cloud center; on the contrary, RSU has a fixed position and thus provides a more stable path to the client. RSU uses WAVE multi-hop communications to deliver the reply to the client. RSU may receive multiple replies, from Cloud services during a short time interval, to deliver to clients; there are generally two possible choices for RSU to communicate with clients: (i) a separate one-to-one WAVE multi-hop path is established between RSU and each client, i.e. *on-demand unicast service* (*Unicasting*); our previous work [4] proposed a solution for this choice, and (ii) RSU aggregates the received replies and simultaneously transmits the data to multiple clients.

This is achieved through an *on-demand multicast tree service*, which is accomplished by simultaneous delivery of specific messages in the form of packets from a source (i.e. RSU) to multiple destinations (i.e. clients). The unicast service requires a considerable DSRC bandwidth and could be responsible for network congestion [23,24,81] since each destination needs a separate end-to-end communication path from the source; if some of destinations are located several hops away from the source, the communication paths will consume considerable DSRC bandwidth along the

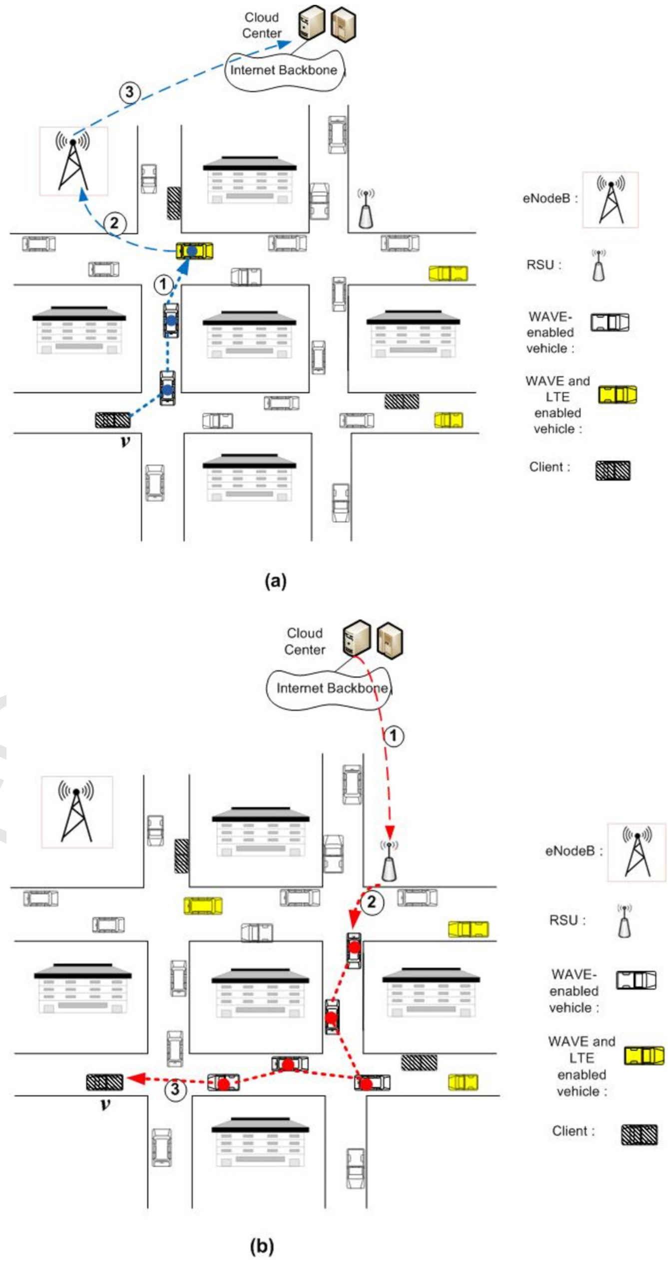

Fig. 1. A typical scenario for client *v* requesting service in HetVNets. The steps are shown in circles: (a) the steps for client *v* sending its request to Cloud Center; (b) the steps for reply message to reach client *v*.

street segments. However, with multicast service, the source can simultaneously support multiple clients, via a multicast tree, saving bandwidth and reducing overall communication congestion [5,16]. In this paper, our focus is on multicast service in VANETs. Nevertheless, provisioning optimum cost multicast tree is considered an NP-complete problem [5,6]. In this paper, we propose two heuristics which efficiently perform in urban VANETs in order to establish multicast tree service from each RSU to its clients.

HetVNets can provide excellent potential for on-demand multicast services. In the following, we present few interesting applications, to be supported in HetVNets that motivate the need for multicast services.

Mobile/fixed gateway: Feasibility of mobile gateways (e.g. vehicles that access Internet via 3G/4G/LTE) has been discussed in the literature [7,8]. Vehicles will be able to request internet access from fixed/mobile gateways. The gateways, then, will aggregate in-

Download English Version:

https://daneshyari.com/en/article/6890073

Download Persian Version:

https://daneshyari.com/article/6890073

Daneshyari.com