Chapter 13
Routing Protocols in Vehicular Ad Hoc Networks

Yuh-Shyan Chen
National Taipei University, Taipei, Taiwan, R.O.C.

Yun-Wei Lin
National Taipei University, Taipei, Taiwan, R.O.C.

ABSTRACT

Vehicular Ad hoc Network (VANET), a subclass of mobile ad hoc networks (MANETs), is a promising approach for the intelligent transportation system (ITS). The design of routing protocols in VANETs is important and necessary issue for support the smart ITS. The key difference of VANET and MANET is the special mobility pattern and rapidly changeable topology. It is not effectively applied the existing routing protocols of MANETs into VANETs. In this chapter, we mainly survey new routing results in VANET. The authors introduce unicast protocol, multicast protocol, geocast protocol, mobicast protocol, and broadcast protocol. It is observed that carry-and-forward is the new and key consideration for designing all routing protocols in VANETs. With the consideration of multi-hop forwarding and carry-and-forward techniques, min-delay and delay-bounded routing protocols for VANETs are discussed in VANETs. Besides, the temporary network fragmentation problem and the broadcast storm problem are further considered for designing routing protocols in VANETs. The temporary network fragmentation problem caused by rapidly changeable topology influence on the performance of data transmissions. The broadcast storm problem seriously affects the successful rate of message delivery in VANETs. The key challenge is to overcome these problems to provide routing protocols with the low communication delay, the low communication overhead, and the low time complexity.

INTRODUCTION

The growth of the increased number of vehicles are equipped with wireless transceivers to communicate with other vehicles to form a special class of wireless networks, known as vehicular ad hoc networks or VANETs (Saha et al., 2004; Xu et al., 2004; Yousefi et al., 2004). Vehicular Ad hoc Network (VANET) is a promising approach for the intelligent transportation system (ITS)

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(ASTM E2213-03, 2003). Vehicle information is delivered via the multi-hop wireless transmission over VANETs to provide safety or comfort applications for drivers. VANETs are expected to improve the traffic quality and provide the more convenient driving environment for the general populace. It is known that VANET (Saha et al., 2004; Xu et al., 2004; Yousefi et al., 2004) is a subclass of mobile ad hoc networks (MANETs) (Briesemeister et al., 2000) . Just like a MANET, a VANET has no the fixed infrastructure. In addition, vehicles with high speed mobility make VANETs having quite different characteristics from MANETs; such as rapidly changed topology and frequently network fragmentation. VANETs are mainly realized in city and highway environments. Roads and streets with intersections is the major scenario in the city environment. Multiple lanes with single or dual direction are investigated in the highway environment. These two environments have different impact on VANETs. In the city environment, packets are difficult to be successfully transmitted since the signals are easily shielded by buildings. With the obstacles, two vehicles are not able to be communicated even if they are very close. In the highway environment, the temporary network fragmentation problem is the key issue. Furthermore, VANETs have distinctive features. For example, power constraint is not the major concern, and location information is easily obtained from GPS (Global Positioning System) (Gerten et al., 2005) which is the common equipment in a vehicle. The interest problem is how to develop the efficient routing protocols in VANETs with the consideration of distinctive features of VANETs.

The design of routing protocols of VANETs is the important issue for supporting the smart ITS. To enhance the safety of drivers and provide the comfortable driving environment, messages for different purposes need to be sent to vehicles through the inter-vehicle communications. According to the number of receiving vehicles within a geographic region, the roles of destinations are divided into three cases: (1) a static destination or a mobile destined vehicle, (2) more than one vehicle in a geographic region, and (3) all vehicles within a geographic region. When the message should be sent to a static destination or a mobile destined vehicle, unicast routing protocol is utilized. Unicast routing is a fundamental operation for vehicle to construct a source-to-destination path in a VANET. Example of unicast routing is given in Figure 1(a). For the case of the static destination, the routing path is quite different because the source vehicle is continuously moving at the different time period. It is more difficult to continuously trace the location of destination vehicle if the destination is a mobile vehicle. Moreover, when the information is delivered to more than one vehicle in a geographic region, multicast and geocast routing protocols are performed. For the geocast routing, if a vehicle receives a geocast packet from neighbors, the packet should be forwarded or dropped depended on its current location. If this vehicle is located in the specific geographic region, the geocast packet is forwarded; otherwise, the packet is dropped. Multicast in a VANET is defined by delivering multicast packets from a single source vehicle to all members of multicast in a multi-hop communications as shown in Figure 1(b). The multicast and geocast routing protocol also are important functions for many useful applications, including collision warning system, distributed games, replicated file systems, and teleconferencing. Broadcast protocol is utilized if the information should be sent to all vehicles in a network. A source vehicle sends broadcast message to all other vehicles in the network. Example is illustrated in Figure 1(c). Broadcast is an important function in many applications of VANETs, such as advertisement publicity, cooperative operations, group discussions, and route discovery. The design issue of broadcasting is how to effectively prevent packet collision and reduce the broadcasting overhead during the broadcasting.