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A Reliable Routing Protocol for Vehicular Ad hoc Networks☆

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ABSTRACT

This paper introduces a Reliable Routing Protocol (R^2P) for Vehicular Ad-hoc Networks (VANETs), which divides the network into overlapping zones. For each zone, a special node is promoted to be the Master Node (MN), which maintains an up-to-date routing boards for inter/intra-zone communication. R^2P depends on two types of boards, namely; Internal Routing Board (IRB) and External Routing Board (ERB). Two types of IRB are used, namely; Zone Routing Board (ZRB) that is maintained by MNs, and Private Routing Board (PRB) that is maintained by each network node. Both ZRB and PRB register routes among zone nodes, while ERB, which is maintained by MN, registers available gateways to neighboring zones. R^2P employs a special route discovery mechanism to discover available routes to the destination, and then elects the most reliable route. It has been compared against the recent VANET's routing protocols. Experimental results have shown that R^2P outperforms the others.

1. Introduction

Recently, the increase in the traffic on roads as well as the frequent usage of vehicles have given an importance to vehicular traffic regulation and vehicle safety improvement on freeways and streets [1]. Moreover, the automotive industry is currently undergoing a state of revolution. Recent advancement in wireless communication technologies has brought a major transition of the vehicle from a simple moving engine to an intelligent carrier system. Vehicular Ad-hoc Networks (VANETs) is a challenging class of Mobile Ad Hoc Network (MANET) that enables nearby vehicles to intelligently communicate with each other and with fixed roadside infrastructure [2] on the move.

VANET communication has recently become an increasingly popular research topic in the area of wireless networking as well as the automotive industries [3]. VANET is an integral component of Intelligent Transport System (ITS) [4] in which moving vehicles are connected and communicate wirelessly to addresses various vehicular traffic issues like traffic congestion, information dissemination [5], accident etc. The goal of VANET research is to develop a vehicular communication system to enable quick, secure [6] and cost-efficient distribution of data for the benefit of passengers' safety and comfort [7]. Although each vehicle in a VANET can act as a router [8], vehicles that are not in each other's direct radio range must communicate in a multi hop manner. Hence, there is a need for a multi hop routing protocol to discover a valid route containing a list of intermediate vehicles from the source to the destination.

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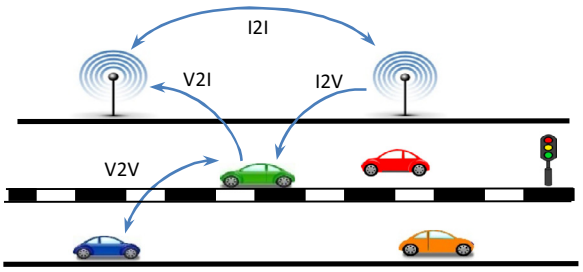

Fig. 1. Types available wireless links.

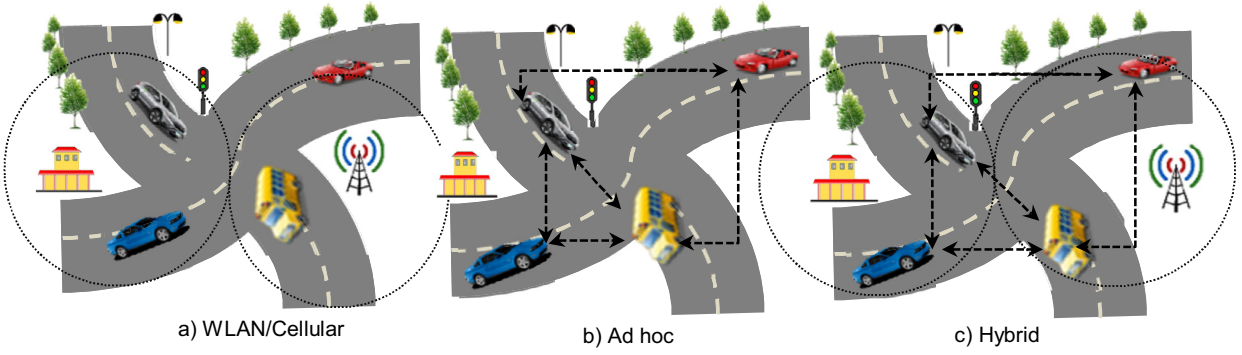

Fig. 2. Different VANET architectures.

Unlike MANETs, VANETs have several challenging characteristics such as; a rapidly changing topology due to the high speed and dynamic behavior of vehicles, low initial neighbor density, varying network size, real time communication, and uneven network density [9]. These restrictions make routing in VANETs even more challenging than routing in MANETs. However, VANETs also provide several important relaxations, such as; (i) vehicles usually own high computation power, (ii) vehicles movements are usually bounded to pre-defined highways and streets, (iii) no energy constraints in VANETs since vehicles usually have enough energy, (iv) vehicles locations can be predicted using several location services such as GPS, and (v) vehicles can access fixed infrastructures installed on road side such as; Wi-MAX, Wi-Fi, etc.

Although road structures are predefined, the connectivity among vehicles breaks very often as vehicles usually move with very high speed [10]. Therefore data routing becomes a very challenge issue in VANET. For routing data, there are several types of wireless communications that can be provided in VANETs. Fig. 1 illustrates the available wireless links, which are; (i) vehicle-to-vehicle (V2V), (ii) vehicle-to-infrastructure (V2I)/infrastructure-to-vehicle (I2V), and infrastructure - to-infrastructure (I2I). V2V enables vehicles to exchange information in a collaborative manner. There is also another wireless communication link between the infrastructure and the nearby vehicles, which can be carried in two directions (e.g., V2I and I2V). Through such link, the infrastructure provides up-to-date information and internet access to vehicles. Hence, they can receive up-to-date information regarding the happenings as well as the traffic on the nearby roads. On the other hand, in I2I communication, the infrastructures share information among each other's in order to keep them up-to-date.

The architecture of VANET consists of three categories, namely; pure cellular/WLAN there were Stationary or fixed gate-ways around the roadsides are used to provide connectivity to vehicles as shown in Fig. 2(a), Pure Ad-hoc in which there is no need for infrastructure but range is limited, used to perform vehicle to vehicle (V2V) as shown in Fig. 2(b), and hybrid which Is the Combination of Cellular and Ad-hoc network as shown in Fig. 2(c) [11].

To deploy VANETs, there must be some commercial applications that benefit from them. The applications here VANET can play a major role can be categorized into two broad categories. The first category is Safety-Related [12] Applications which used to increase the safety on the roads like Collision Avoidance [13], Cooperative Driving, and Traffic optimization and the other category is User Based Application which Provide the user infotainment like Internet Connectivity [14] and etc.. On the other hand, VANET is an application of MANET but it has its own distinct characteristics [15] which are High Mobility, Rapidly changing network topology, Unbounded network size, Frequent exchange of information, Wireless Communication, Sufficient Energy, and Better Physical Protection. Although the characteristics of VANET distinguishes it a different network but some characteristics imposes some challenges to deploying the VANET. These challenges [16] can be categorized into several categories, which are Technical Challenges That deal with the technical obstacles which should be resolved before the deployment of VANET, and Social and Economic Challenges.

Reliability is the most challenging problem in rabidly dynamic networks such as VANETs. A valid route may become invalid after a moment. Resorting to shortest routes for data transmission among network nodes without considering the

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