Applying Vehicular Ad Hoc Networks for Reduced Vehicle Fuel Consumption

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Abstract. With recent advances in the development of wireless communication networks, Vehicular Ad hoc Networks (VANETs) have been receiving considerable research interest. One of the major applications of VANETs is Intelligent Transportation Systems (ITS). To exchange and distribute messages, geocast protocols have been proposed for ITS. Almost all of these protocols evaluate network performance level, instead of evaluating the protocol impact on the vehicular system. Nowadays, many drivers are becoming increasingly concerned with rising fuel cost. Therefore, it is desirable to create new "economical" geocast (EG) protocols. The main goals of this paper are to motivate communications researchers to design EG protocols, demonstrate the ability to integrate fuel consumption models with VANETs, and illustrate the necessity of transmitting information to vehicles in order for drivers to choose the economical path. Simulation results demonstrate that significant amounts of fuel will be saved if such an EG protocol is used.

Keywords: fuel consumption, economical geocast, intelligent transportation systems, vehicular ad hoc networks.

1 Introduction

During the past several years, fuel prices in many countries have been rising considerably. For instance, the gasoline price in western Canada almost doubled from about 53 cents/liter in 1998 to 102 cents/liter in 2009 [1]. Fuel expenditure has become significant enough, so that people in many countries need to take it into consideration when allocating their budget. Therefore, new ways to reduce fuel expenditure are needed to be introduced.

A significant amount of fuel is wasted due to drivers getting lost or not taking a very direct route to their destination, high acceleration, stop-and-go conditions, congestion, long distance routes, high speeds, and vehicle's model and year. In case of vehicle's model, some organizations, such as Office of Energy Efficiency (OEE) in Canada are mandated to lead citizens to energy efficiency at home, at work, and on the road [2]. OEE published a fuel consumption guide in cooperation with vehicle manufacturers, Natural Resources Canada (NRCan),

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and Transport Canada (TC) [3]. This guide assists people, particularly those who want to purchase a new vehicle, by comparing relative fuel consumption ratings among vehicles of different models. The other cases can be alleviated by implementing Intelligent Transportation Systems (ITS).

ITS is a mixture of tools such as software, hardware, traffic engineering concepts, and communication technology that can be integrated in order to be applied to the transportation system to improve its efficiency and safety [4]. In ITS technology, navigation (e.g., Google Map) is a fundamental tool that helps driver select a suitable path such as the shortest path. In [5], a navigation tool has been designed especially for minimizing fuel consumption and vehicle emissions. To alleviate congestion, a number of scheduling methods have been proposed [6,7]; however, it is not always that vehicles passing the uncongested route consume less fuel than ones on the congested route.

Various forms of wireless communications technologies have been proposed for ITS. Vehicular ad hoc networks (VANETs) are a promising research area in ITS applications [8]. With VANETs, drivers can be informed about all kinds of events and conditions, which could impact their travel. To exchange and distribute messages, broadcast or geocast routing protocols have been proposed for ITS applications [9,10,11]. Almost all these protocols evaluate network-centric performance level (e.g., message delays, packet delivery ratio, etc.), instead of evaluating the impact of the protocol on the vehicular system (e.g., fuel consumption, emissions, travel time, etc.).

In this paper, the impact of using a geocast protocol on the vehicle fuel consumption is studied. To the best of our knowledge, our attempt is a first in the field. Designing or proposing the communication protocols that are suitable in applications such as reducing fuel consumption is out of the scope. The main contributions of this work are to:

- Motivate researchers working in the field of communication to design economical geocast protocols, which means geocast protocols that focus on minimizing fuel consumption, thus saving money;
- Demonstrate the ability to integrate fuel consumption models with vehicular networks;
- Illustrate the necessity of sending information to vehicles in order for drivers to choose an appropriate path to a target to minimize fuel consumption.

The remainder of this paper is organized as follows. The research background is reviewed in Section 2. Our system model is described in Section 3, including traffic model, accident model, fuel consumption model, and communication system. Simulation results are presented in Section 4. In Section 5, main issues to design an economical geocast protocol have been discussed. Finally, conclusions are drawn in Section 6.

2 Background

This research brings together two key areas: vehicle fuel consumption models and geocast protocols.