Geocast Routing in Vehicular Networks for Reduction of CO_2 Emissions

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Abstract. Pollution and gas emissions are increasing and negatively impacting global warming. Consequently, researchers are looking for solutions that save environment. Greenhouse gas (GHG) emissions from vehicles are considered to be one of the main contributing sources. Carbon dioxide (CO_2) is the largest component of GHG emissions. Vehicular networks offer promising technology that can be applied for reduction of CO_2 emissions. One of the major applications of vehicular networks is Intelligent Transportation Systems (ITS). To exchange and distribute messages, geocast routing protocols have been proposed for ITS applications. Almost all of these protocols evaluate network-centric performance measures, instead of evaluating the impact of the protocol on the vehicular system. Nowadays, the harmful effects of air pollutants have been the subject of considerable public debate. Vehicles' stop-and-go condition, high speed, and high accelerations are environmentally unfriendly actions (EUF) that increase the amount of emissions. These actions can happen frequently for vehicles approaching a traffic light signal (TLS). Therefore, we propose a new protocol named environmentally friendly geocast (EFG), which focuses on minimizing CO_2 emissions from vehicles approaching a TLS by avoiding the EUF actions. Simulation results demonstrate that the proposed protocol can achieve effective reduction of vehicle CO_2 emissions.

Keywords: CO_2 emissions, environmentally friendly geocast, intelligent transportation systems, vehicular ad hoc networks.

1 Introduction

The detrimental effects of air pollution and concerns about global warming are being increasingly reported by the media. Greenhouse gas (GHG) emissions from vehicles are considered one of the main contributing sources. Carbon dioxide (CO_2) is the largest component of GHG emissions. For example, in Japan in 2008, the amount of CO_2 emissions from vehicles (200 million ton) is about 17 percent of the entire CO_2 emissions from Japan (1200 million ton) [1]. The

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Kyoto Protocol aims to stabilize the GHG concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system [2].

With increasing public awareness of the need for reduced GHG emissions from vehicles, it is important to address this problem by effectively using the capability of information technology before spending more on new roads. Geocast protocols in vehicular networks technologies are a promising research area in Intelligent Transportation Systems (ITS) applications. The main actions affecting the increase in the amount of emissions include acceleration, high speed, drivers getting lost or not taking a very direct route to their destination, idling cars on the road, stop-and-go conditions, choosing a path according to a navigation system that later becomes congested and inefficient after committing to that path. The question then becomes what role do geocast protocols play in vehicular networks to reduce the impact of some of these actions?. This paper focuses on reducing the impact of stop-and-go conditions, high speeds, and high accelerations.

The effect of speed and acceleration on vehicle CO_2 emissions can be investigated by using an emission model. Emission models have been studied in [3]. According to that study, the Virginia Tech Microscopic model (VT-Micro) is superior to the other models in its accuracy. To study the impact of vehicle speed, the vehicle acceleration is set to a constant value (say 0 kph/s). After that, the CO_2 emissions are computed with different values of speed using VT-Micro model. Figure 1 shows that CO_2 emissions increase with high speeds. Similarly, to show the effect of vehicle acceleration, the vehicle speed is set to 30 kph. Then, the CO_2 emissions are calculated with different values of accelerations. Figure 2 demonstrates that negative accelerations do not affect the CO_2 emissions much because vehicles do not exert power in negative accelerations. On the other hand, the amount of vehicle CO_2 emissions increases with increasing the vehicle acceleration. As a result, it is logical to propose an existing scenario where some environmentally unfriendly (EUF) actions happen frequently. Based on this scenario, the capability of information technology has to be utilized to help avoid or reduce these actions.

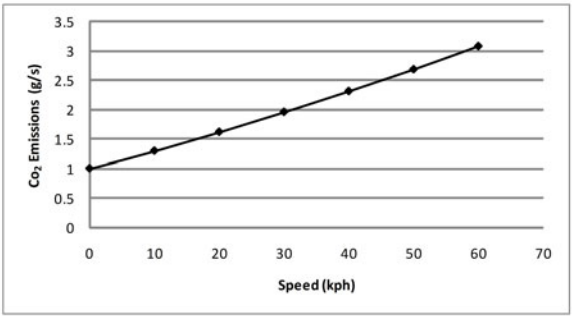

Fig. 1. The impact of speed on vehicle CO_2 emissions