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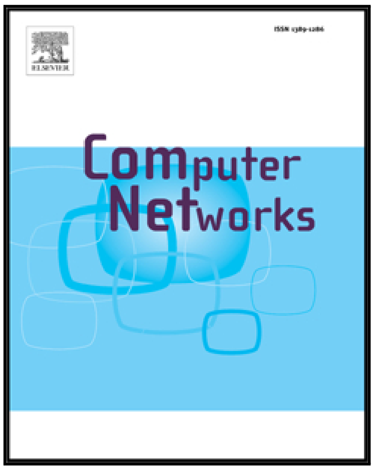

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Two-Way Traffic Link Delay Modeling in Vehicular Networks

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Abstract

This paper proposes a modeling of expected link delay (i.e., data delivery delay) on a two-way road segment for carry-and-forward data delivery schemes in vehicular networks. Recently, a lot of vehicles can communicate with each other by dedicated short-range communications (DSRC) for vehicular networking. In the near future, more vehicles will be equipped with DSRC devices because of governmental policies for driving safety. In this paper, we derive a link delay model on a two-way road segment. This link delay model is essential to support multihop infrastructure-to-vehicle or vehicle-to-vehicle data delivery in vehicular networks as disruption tolerant networks. Through simulation, it is shown that our two-way link delay model is more accurate than the legacy two-way link delay model. Furthermore, by applying our model to data unicasting, we show that our model is precise enough to support the efficient data unicasting on vehicular networks.

Keywords: Vehicular Networks, VANET, Two-way, Link Delay, Data Forwarding.

1. Introduction

Nowadays, Vehicular Ad Hoc Networks (VANETs) have been researched widely and intensively. The importance of VANET is getting higher as the demand on vehicular networks increases for communications among vehicles for the driving safety and Internet connectivity [1, 2]. For example, a vehicle in a blind spot can be detected by inter-vehicle communications and a smartphone can give a pedestrian an alarm message when a vehicle is approaching from behind. This communications is achieved by Dedicated Short-Range Communications (DSRC) devices [3]. As U.S. Department of Transportation tries to mandate to equip DSRC devices to all light vehicles [4] for the driving safety, a lot of vehicles will be equipped with DSRC devices in the near future. This technology will be more important as autonomous vehicles are under development by major automotive vendors, such as Audi [5], Ford [6], and Mercedes-Benz [7]. Furthermore, inter-vehicle communications can facilitate the Internet connectivity of vehicles through Road-Side Units (RSUs) [8], which are connected to the Internet. This communications can reduce the dependency on 4G-LTE networks with cost effectiveness.

In multihop infrastructure-to-vehicle data delivery, accurate link delay is required for reliable unicast [2] or multicast [9] data delivery. With such reliable data delivery, customized notification delivery services can be offered [10]. For example, when an accident happens either at an intersection or in a road segment, with multihop Infrastructure-to-Vehicle (I2V) data delivery, Traffic Control Center (TCC) promptly disseminates the accident notification to each relevant vehicle that will pass through the accident road spot according to its navigation path. By this customized notification, the relevant vehicles will be able to detour more proactively and efficiently for better navigation. Many data forwarding schemes [2, 9] are based on one-way link delay model (i.e., the expected data delivery on a road segment with one-way road traffic). However, two-way roads are dominant over one-way roads in real road traffic environments. In the two-way roads, vehicles moving on both directions (i.e., forward and backward traffic for a directed road segment) can be used for rapider data forwarding than vehicles moving on only one direction because more vehicles on both directions participate in data forwarding than those on one direction. We define two-way road link delay (called two-way link delay) as the delay that a packet takes to move from the entrance to the exit in a *two-way traffic road segment* by the packet forward-and-carry process of vehicles [1, 2]. On the other hand, we define one-way road link delay (called one-way link delay) as the delay that a packet takes to move from the entrance to the exit in a *one-way traffic road segment* by the packet forward-and-carry process of vehicles [1, 2]. It is clear that a link delay modeling in a two-way traffic road segment can provide rapider and more reliable packet delivery service for vehicles than a link delay model in a one-way traffic road segment. Thus, this paper proposes a formulation of expected link delay for a two-way road segment as a two-way link delay model, assuming that the road length, average arrival rate, and vehicle speed are available. Our intellectual contributions are as follows:

- Two-way link delay model. We propose a two-way link delay model on a road segment by utilizing road statistics

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