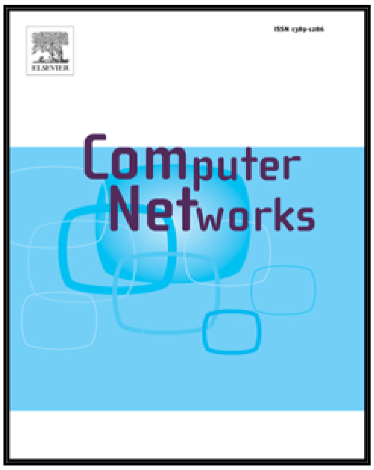

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Improving Flow Delivery with Link Available Time Prediction in Software-Defined High-Speed Vehicular Networks

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Abstract

Due to the high-speed mobility of vehicles, reliable data delivery in vehicular networks is still a challenge. In this paper, we propose a link available time prediction based backup caching and routing (LBR) scheme in software-defined high-speed vehicular networks. In order to improve flow delivery performance, several modules, such as information awareness and link prediction modules, are designed in this software-defined architecture. Taking advantage of the embedded modules, the controller predicts the link remaining duration for each vehicle timely by the location and velocity information. The controller also establishes routing policies for flows with different duration by using LBR algorithm. Finally, the simulation scenario is set to a high-speed vehicle-to-infrastructure (V2I) network. The vehicle is a high-speed train. The roadside infrastructures belong to cellular networks. For comparison, greedy perimeter stateless routing with lifetime (GPSR-L) is introduced. The results demonstrate that our scheme outperforms GPSR-L with an improvement in the successful transmission. Further, we explore the benefit and cost of the backup caching compared with link prediction based routing (LR) algorithm. The results show that the backup caching of LBR enhances LR algorithm with the sacrifice of a reasonable cost.

Keywords: Vehicular network, Link availability time prediction, High-speed mobility.

1. Introduction

Vehicular networks have been regarded as a promising technology for the enhancement of traffic safety, traffic efficiency, and entertainment services [1]. In vehicular networks, vehicles are allowed to communicate with infrastructure (V2I), vehicles (V2V), and other networking devices (V2X) through on-board sensing, computing, and wireless devices [2]. These vehicular networks present unique characteristics and challenges in terms of mobility, connectivity, topological changes, prioritization of data packets, security and privacy, and so on [3]. For example, vehicular networks have a highly dynamic network topology and limited connected duration due to vehicle mobility [4].

The high-speed vehicular network is a specific vehicular network scenario, which has different characteristics from the low-speed regular vehicular network. Low-speed regular vehicular networks, such as urban vehicular networks, mainly focus on the security and privacy issues [5], and routing issues of emergency data dissemination [6]. Research for other issues, such as mobility and connectivity [7, 8], has mainly been studied in V2V, with little attention paid to V2I. This is because that vehicles in low-speed mobility usually stay at a base station for a long time. However, these issues have become particularly serious in high-speed vehicular networks, since the connection duration becomes very short. Taking the high-speed train communication system as an example, the channel presents the features of time-varying and large Doppler shifts, unpredictable noise and ambient interference, which significantly differs from the channel in low mobility networks [9]. The connectivity of wireless links established by high-speed trains is interrupted and re-established more frequently, resulting in a significant degradation of network performance [10].

However, in general, routing mechanisms cannot respond to the change of link status in real time to provide a reliable communication. In order to provide a stable communication quality and reliable data delivery, the routing algorithm should aim at routing to a path with sufficient time to exchange information. Thus, predicting link availability gives the foresight for routing algorithms in complex and changeable networks [11]. A number of prior works have studied the link prediction in complex networks [12], mobile networks [13], and vehicular networks [14]. The link prediction algorithms presented in [12, 13] focus on the probability of link interruptions in order to prevent transmission losses. However, they don't pay attention to the link available duration which is an important metric in vehicular networks. The link duration prediction problem has been studied in [15–18]. Unfortunately, these works cannot be directly applied to the high-speed vehicular communication system since they are mainly concentrated on V2V connection and low-speed mobility models on roadways. Therefore, reliable

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