Chapter 18
Co-Operative Load Balancing in Vehicular Ad Hoc Networks (VANETs)

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ABSTRACT

Recently data dissemination using Road Side Units (RSUs) in Vehicular Ad Hoc Networks (VANETs) received considerable attention for overcoming the vehicle to vehicle frequent disconnection problem. An RSU becomes overloaded due to its mounting location and/or during rush hour overload. As an RSU has short wireless transmission coverage range and vehicles are mobile, a heavily overloaded RSU may experience high deadline miss rate in effect of serving too many requests beyond its capacity. In this work, the authors propose a co-operative multiple-RSU model, which offers the opportunity to the RSUs with high volume workload to transfer some of its overloaded requests to other RSUs that have light workload and located in the direction in which the vehicle is heading. Moreover, for performing the load balancing, the authors propose three different heuristic load transfer approaches. By a series of simulation experiments, the authors demonstrate the proposed co-operative multiple-RSU based load balancing model significantly outperforms the non-load balancing multiple-RSU based VANETs model against a number of performance metrics.

INTRODUCTION

The Federal Communications Commission (FCC) allocates the 5.850 to 5.925 GHz frequency band for vehicle to vehicle and vehicle to Road Side Units (RSUs) communication. A number of applications has been envisioned in Vehicular Ad Hoc Networks (VANETs) such as road safety, driving assistance, emergency public service, business, entertainment etc. (Schoch, Kargl, & Leinmüller, 2008), as well as internet service from on board vehicles (Lee, Ernst, & Chilamkurthi, 2011). In VANETs, as vehicles are normally on the move, vehicle to vehicle frequent disconnection is very common. Recently a number of researchers have proposed RSU-based VANETs to handle this
connectivity problem (Zhang, Zhao, & Cao, 2010; Schoch, Kargl, & Leinmüller, 2008; Lochert, Scheuermann, Caliskan, & Mauve, 2007). In this kind of model, RSUs are placed along roadside to provide vehicle to infrastructure (V2I) connectivity (Liu & Lee, 2010; Chang, Cheng, & Shih, 2007). RSU is a stationary infrastructure which acts like a server, with memory storage, substantial computational capacity and short wireless range transmission system. RSUs are usually placed at locations with high vehicle density such as at the intersection of roads, market places, gas stations, bus terminals etc. The RSU-based VANETs model is very useful during unfriendly VANETs environment (off peak hour, night time etc.) and on highways where vehicle density is usually low (Lochert, Scheuermann, Caliskan, & Mauve, 2007). In our proposed co-operative multiple-RSU model, an RSU acts as a buffer point (Zhang, Zhao, & Cao, 2010) which stores the information that is useful for the vehicles, RSUs are interconnected, know the workload information of each other and can exchange their workloads.

A given RSU may experience heavy workload during the peak hours and some requests may not get serviced due to overload. To alleviate this problem, we propose transferring workload to less heavily loaded RSUs, where each RSU use the DSIN on-demand scheduling algorithm (Zhang, Zhao, & Cao, 2010; Ali, Chan, & Li, 2011) to give priority to delay sensitive and smaller sized popular data items for scheduling the RSU received queue requests and we propose a number of heuristic load transferring approaches for performing the load balancing.

**RELATED WORK**

Considerable researches have been carried out to find a stable data dissemination infrastructure in highly mobile and sparsely connected VANETs environments (Chen, Kung, & Vlah, 2001; Wu, Fujimoto, Guensler, & Hunte, 2004; Zhao, Zhang, & Cao, 2007; Zhao & Cao, 2008). Nadeem, Shankar, and Iftode (2006) formulate a data push communication model for vehicle to vehicle communication without any road side infrastructure support. Zhang, Zhao, and Cao (2010) provide a single RSU-based VANETs model which maintains both upload and download queues and try to get the service balance among them. Yi, Bin, Tong, and Wei (2008) provide a mesh RSUs infrastructure based VANETs on both space and time dimensions and formulate reliability and fairness based algorithms. Ali, Chan, and Li (2011) analyze the performance of different on-demand scheduling algorithms for incorporating upload queue with download queue in RSU-based VANETs. Chen, Cao, Zhang, Xu, and Sun (2009) study the performance of the effectiveness of certificate revocation distribution in VANETs with and without enabling vehicle to vehicle communication. Liu and Lee (2010) analyze dynamic traffic characteristics in RSU-based VANETs. They propose to use different channels to disseminate different types of data and apply push and pull data dissemination technique based on the volume of requests at RSU server.

Some researchers study the performance of on-demand scheduling algorithms for data dissemination in real-time environments (Lee, Wu, & Ng, 2006; Liu & Lee, 2010; Xu, Tang, & Lee, 2006; Wu & Cao, 2001).

However, none of the above works considers co-operative load balancing among multiple RSUs to share the load among all RSUs in the networks and improve overall system performances.

**SYSTEM MODEL**

**RSU Architecture**

We assume VANETs services are provided to the vehicles at hot spots such as gas stations or intersections of the roads, where the density of vehicles is typically higher than other areas. RSUs