Chapter 48
Vehicular Cloud Computing:
Trends and Challenges

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ABSTRACT

Recently, Vehicular Ad Hoc Networks (VANET) have attracted the attention of research communities, leading car manufacturers, and governments due to their potential applications and specific characteristics. Their research outcome was started with awareness between vehicles for collision avoidance and Internet access and then expanded to vehicular multimedia communications. Moreover, vehicles' high computation, communication, and storage resources set a ground for vehicular networks to deploy these applications in the near future. Nevertheless, on-board resources in vehicles are mostly underutilized. Vehicular Cloud Computing (VCC) is developed to utilize the VANET resources efficiently and provide subscribers safe infotainment services. In this chapter, the authors perform a survey of state-of-the-art vehicular cloud computing as well as the existing techniques that utilize cloud computing for performance improvements in VANET. The authors then classify the VCC based on the applications, service types, and vehicular cloud organization. They present the detail for each VCC application and formation. Lastly, the authors discuss the open issues and research directions related to VANET cloud computing.

INTRODUCTION

Recently, the growth in the number of vehicles on the road has put great stress on transportation systems. This abrupt growth of vehicles has made driving unsafe and hazardous. Thus, existing transportation infrastructure requires improvements in traffic safety and efficiency. To accomplish this, Intelligent Transportation Systems (ITS) have been considered to enable such diverse traffic applications as traffic safety, cooperative traffic monitoring and control of traffic flow. These traffic applications would become realities through the emergence of VANET because it is considered

as a network environment of ITS. The increasing necessity of this network is an impetus for vehicle manufacturers, research communities and government agencies to increase their efforts toward creating a standardized platform for vehicular communications (for instance, Vehicle Safety Communication Consortium, Network-on-Wheels and Honda's Advances Safety Vehicle Program (Olariu, 2009). In particular, the 5.9 GHz spectrum band has been allocated for licensed Short Range Communication (DSRC) between vehicles. In addition, in the near future, more vehicles will be embedded with devices that facilitate communication between vehicles, such as Wireless Access in Vehicular Environment (WAVE) (ITS-Standards, 1996). When vehicles are equipped with WAVE, they can communicate with nearby cars and access points within their coverage area.

In addition, car manufactures have advanced and hence fitted out better storage, computation and communication devices in the vehicles. These advances are all for the sake of improving traffic safety and efficiency (Ghafoor, 2013a), (Sommer, 2010), (Ghafoor, 2013b). A long with this development, vehicles can also access internet services and thereby various benefits will be offered to the drivers and passengers (Hussain, 2012). Thus, these advancements in vehicular technology and communication will provide wide potential applications to meet safety and comfort requirements for driver. However, the phenomenal on-board resources are remaining under-utilized by the aforementioned applications (Li, 2007).

In an attempt to address the problem of resource under-utilizing, the authors in (Eltoweissy, 2010) have proposed the concept of vehicular cloud. VCC is defined as paradigm shift from conventional VANET to vehicular cloud in which vehicles use their on-board resources and cloud resources as well (Olariu, Khalil, & Abuelela, 2011; Abid, 2011). The motivation of merging mobile cloud computing with VCC is the dynamic accessibility

of resources. In other words, the VCC follows the concept of pay as you go model instead of buying resources and infrastructure. With this technology, vehicle's communication, computing and storage capabilities can be combined with those of other drivers or rented to the participated cars. This concept is similar to the traditional cloud computing but sensing nodes in VANET are vehicles and they travelling with high speed. VCC is still in its infancy stage of researching and need to be explored more (Arif, 2012). Figure1 shows the number of articles published in the last years.

In this Chapter, we surveyed the state-of-arts of vehicular clouds, which is considered as a development of traditional cloud computing with novel features. More precisely, the aims of this Chapter are to introduce the concepts of vehicular clouds and highlight the prospective applications for sake of improving the efficiency of vehicular networks. We explained the existing techniques that utilize cloud computing for performance improvements in VANET. We then classified the VCC based on the applications, services types and vehicular cloud organization. Moreover, we explained the communication paradigm and organization of vehicular clouds. Based on this though study on VCC, we discussed the open issues and research directions related to VANET cloud computing. To the best of our knowledge, this research paper is the first attempt in thoroughly reviewing state-of-arts of VCC and highlighting its challenges.

The rest of the Chapter is organized as follows: introduction section provides an overview of the current state of the arts of VANET. The cloud computing taxonomy and its illustration are discussed in CC section, followed by the discussion on vehicular cloud computing and its architecture, where we also highlight the applications of vehicular clouds and the layers of the vehicular clouds. Finally, conclusion section concludes the chapter and discusses future directions.

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