A Cloud-Based Incentive Mechanism for Sensing in Mobile Sensor Networks

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ABSTRACT

Due to proliferation of smart cities and other smart services, extensive data collection needs to be accomplished by mobile sensor networks (MSNs). However, sensing and data collection are voluntary tasks for many MSN users. For example, drivers are not required to report traffic condition although their vehicles with advanced sensors have easy access to critical information. Therefore, incentive mechanisms are needed to recruit sensing users (SUs). Incentive mechanisms proposed for traditional MSNs cannot be applied directly due to limited information of SU used for recruitment. In this article, the authors propose a novel cloud-based MSN model that consists of three parties, including data request party, cloud-based platform and SUs. To better utilize information of SUs, a data quality model is proposed to measure the credit level of SUs. The proposed SU recruitment strategy takes into consideration social connections of users. According to the strategy, SUs are divided into two separate levels. Moreover, the authors propose an incentive mechanism using a Stackelberg game theoretical approach to achieve the maximum utility of each recruited SU. The simulation results demonstrate that the proposed incentive mechanism can recruit SUs more efficiently while providing data quality guarantee.

KEYWORDS

Cloud, Credit Level, Incentive Mechanism, Mobile Sensor Networks, Stackelberg Game

INTRODUCTION

Mobile devices such as smart phones, tablets, and vehicles are equipped with advanced sensors to provide services in many areas, e.g., smart cities, smart grids, smart homes, etc. (Kazman & Chen, 2009; Lane & Miluzzo & Peebles & Choudhury, 2010). Moreover, wireless networks and powerful computing capabilities of current mobile devices advanced the traditional mobile sensor networks (MSNs) to be deployed in various applications, such as environmental monitoring and public infrastructure monitoring (Mathur, Kasturirangan, Chandrashekhara, Xue, Gruteser & Trappe, 2010; Mohan, Padmanabhan & Ramjee, 2008).

A typical MSN structure is shown in Figure 1. As we can see, a traditional MSN consists of sensing users (SUs) and a platform, which is a powerful backend service in most cases. The platform

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is responsible for recruiting SUs in network operation and gathering sensing data from SUs. Incentive mechanisms are widely adopted to motivate SUs to join sensing tasks by the MSN platform. Due to limited computing power and restricted physical deployment of the platform in traditional MSNs, applications of MSN are relatively small in scale and coverage. With the advanced cloud computing technologies, cloud-based MSN (CMSN) can be deployed to enable cloud-based platform (CP). A CP has advantages in computing power and flexible deployment (Jiau, Huang, Hwang & Vasilakos, 2015; Chenaru, Stamatescu, Stamatescu & Popescu, 2015; Fan, Peng, Yuan, Chen, Hu & Zhang, 2015). However, cloud applications in CMSN have not been widely studied yet. With the development of internet of things (IoT), sensing tasks and devices are more diversified than ever (Pouryazdan, Fiandrino, Kantarci, Kliazovich, Soyata & Bouvry, 2016; Amarlingam, Mishra, Prasad & Rajalakshmi, 2016). For example, SUs can be vehicles for live traffic monitoring (Xu, Wolfson & Cho, 2011). SUs may also be sensors for health condition monitoring, etc. (Li, Guo & Guo, 2014; McNamara & Ngai, 2016). With various kinds of devices and sensing tasks involved, it is important to motivate and recruit a number of SUs by using CMSN. Sensing and transmitting data would consume extra energy of an SU. Moreover, an SU may rely on metered data subscription for connection. Therefore, it is reasonable to assume that no user would volunteer to do sensing tasks and transmitting sensing data without profit. To improve the efficiency of SU recruitment, social relationship of SUs is introduced in the proposed mechanism. There has been research work on incentive mechanism design for MSNs (Yang, Xue, Fang & Tang, 2015; Ji & Chen, 2016; Luo, Kanhere, Das & Tan, 2015; Jordan, Sheptykin, Gruter & Vatterrott, 2013). However, most of them did not consider sensing data quality. Moreover, few existing work considered using the social connections of the SUs to improve recruiting efficiency.

In this paper, we propose a novel CMSN model for SU recruitment. In the proposed mode, there are three parties, namely data request party (DRP), CP and SUs. DRP can outsource the sensing data request to CP. CP can provide sensing services that not only sense data gathering but also sense data computing for DRP depending on different applications. SU recruitment process in traditional MSN platform is usually random. However, CP can analyze sensing characteristics of SUs based on their historical sensing information, e.g., sensing data quality, which can be a reference for SU recruitment. Based on the CMSN model, we then propose a sensing data quality model. The model is used to classify SUs into different credit levels. Moreover, both social connection of SUs and data quality requirement of DRP are taken into consideration in the proposed incentive mechanism to motivate SUs with certain sensing data quality into sensing tasks.

The contributions of this paper are as follows. First, a CMSN model with three parties as DRP, CP and SUs is proposed. The sensing data requirement of DRP is included in the CMSN model. Second, a sensing data quality model used to classify SUs into different credit levels is proposed.
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