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Incentive Mechanism for Mobile Crowdsensing

A Game-theoretic Approach

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Preface

Mobile Crowdsensing (MCS) is emerging as a novel sensing paradigm in the Internet of Things (IoTs) due to the proliferation of smart devices (e.g., smartphones, wearable devices) in people's daily lives. These ubiquitous devices enable the possibility of harnessing the wisdom of crowds by recruiting mobile users to collectively perform sensing tasks that largely collect data about a diverse range of human activities and the surrounding environment. However, users suffer from resource consumption like battery, computing power, and storage, which discourage users' participation. To ensure a participation rate, it is necessary to employ an incentive mechanism to compensate users' costs such that users are willing to take part in crowdsensing. Designing an appropriate incentive mechanism is nontrivial due to different practical challenges like modeling and computational hardness. Capturing the different roles' utility maximization, game theory is widely used to address incentive mechanism design problems. While many existing papers study incentive mechanism in MCS, to the best of our knowledge, there is few books giving a comprehensive review of the incentive mechanism for MCS, especially from the game-theoretic perspective. This book aims to fill this void.

This book sheds light on designing incentive mechanisms for MCS in the context of game theory. Particularly, we present several game-theoretic models for MCS in different scenarios. In these game-theoretic models, many techniques are involved, such as the Stackelberg game, online learning, Lyapunov optimization, convex optimization, KKT condition, equilibrium analysis, and utility modeling. The purpose of this book is to fill in the book publishing gaps, especially in considering how game theory is applied to address incentive mechanism design problems for MCS.

This book is of particular interest to the readers and researchers in the field of IoT research, especially in the inter-discipline of network economics and IoT, because this book brings a number of innovative game-theoretic technologies to summarize the incentive mechanism and how to use this a set of model frameworks to address the practical issues of data collection in MCS.

The main benefits of reading this book include: (1) summarizing the game-theoretic incentive mechanism model and practice of MCS; (2) understanding the importance and design principle of incentive mechanism for MCS; (3) drawing inspiration from the book's specific data collection applications, which provide game-theoretic solutions for designing incentive mechanism in more practical MCS fields.

The prerequisite for reading this book is a basic understanding of the mobile crowdsensing infrastructure, game theory, equilibrium analysis, and convex optimization.

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Contents

Chapter 1
A Brief Introduction

Abstract In this chapter, we first introduce the background regarding Mobile Crowdsensing (MCS) and present an overview of MCS. Then, we specifically state the incentive mechanism design problem for MCS. Finally, we demonstrate the book structure for convenience.

Keywords Mobile crowdsensing · Architecture · Incentive mechanism · Game theory

1.1 Overview of Mobile Crowdsensing

Recently, the proliferation and prevalence of mobile devices enable a new kind of sensing paradigm, mobile crowdsensing (MCS) [1, 2], which allows a platform to collect data from on-site users carrying mobile devices anywhere and anytime. Therefore, MCS has revolutionized the traditional sensing paradigm (e.g., Wireless Sensor Networks, WSN) in the Internet of Things (IoT), which enables a large number of successful crowdsensing applications that cover and affect people's daily lives.

Typically, the architecture of MCS is illustrated in Fig. 1.1 where an MCS system is made up of several requesters, a platform and a large number of mobile users. These three parties interact in the MCS system:

- Requester: An entity that has sensing demand and generates sensing tasks over time. Note that we focus on a scenario where multiple requesters generate tasks;
- User: A task actuator who has sensing and computing capability to perform tasks. There are multiple users working in the MCS system;[1]
- Platform: An intermediate who collaborates the interaction between requesters and users (i.e., receives tasks from requesters and allocates them to users).

[1] As shown in Fig. 1.1, the user can be a vehicle with general-purpose sensors.

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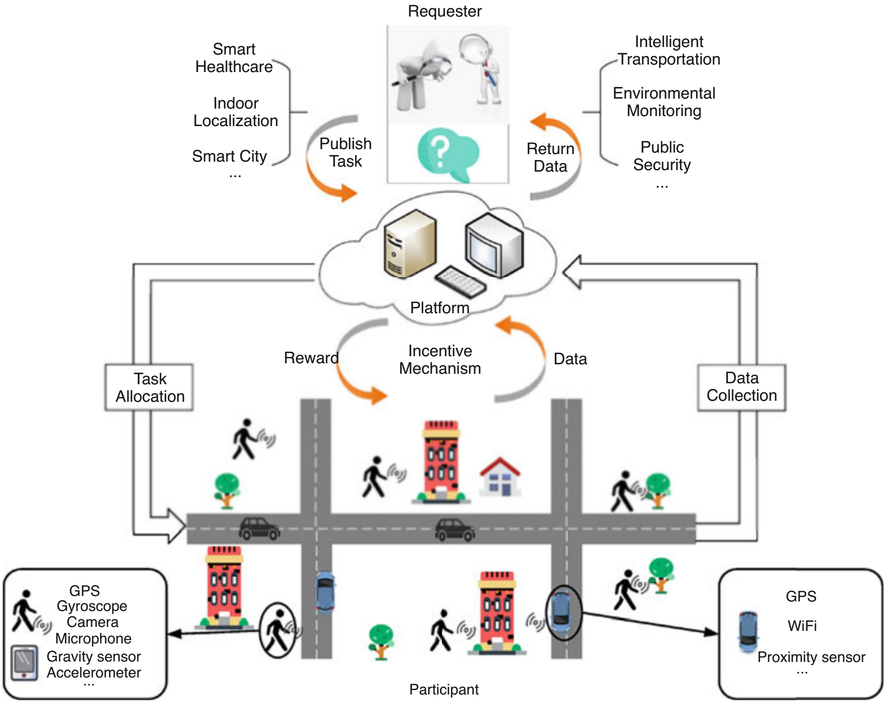

Fig. 1.1 Illustration of crowdsensing architecture

Generally speaking, downstream applications like healthcare [3–5], smart transportation [6–8], smart city [9–11], environmental monitoring [12, 13], accurate localization [14–16], social networking [17] are developed based on the data-related services. These applications are usually time-sensitive and location-aware. To guarantee applications' quality of service (QoS), real-time and location-aware sensing data should be collected. However, on the one hand, the service provider (i.e., requester) cannot perform the data collection individually. On the other hand, current mobile devices (e.g. smartphones, tablets, wearable equipment) grow ever-increasingly. Moreover, mobile devices are commonly held by people anywhere and anytime and are increasingly embedded with various sensors (accelerometer, thermometer, gyroscope, GPS, microphone, and camera). If all kinds of "super sensors" together contribute to crowdsensing, it will be the unprecedented sensing network in the world. Realizing the potential of crowdsensing, a platform is giving rise to serve the requesters by harnessing the power of the crowd to collectively complete large-scale sensing tasks. Therefore, MCS streamlines data collection and enhances the value of easily-generated data from mobile users.

From Fig. 1.1, we can observe that task allocation (or user selection), result aggregation (or quality management) and incentive mechanism are three main studied problems in this area. Among them, designing an effective incentive