Crowdsourcing of Sensor Cloud Services

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To my parents, Aliakbar and Fereshteh, my brothers, Armin and Arash, and my sisters, Parisa and Zari.

Azadeh Ghari Neiat

To my wife and best companion and friend, Malika.

Athman Bouguettaya

Foreword

Recent technological advances allow everyday physical objects to be connected to the Internet and provide their services on the Web. The Internet of Things (IoT), which is widely regarded as the leading technology that will change our world in the coming decade, offers the capability to integrate and connect both digital and physical entities. With a network of cheap sensors and interconnected things, the information we collect about our world will be generated at a much higher granularity from IoT devices. Successful deployment of IoT solutions will allow for safer roads, better use of public transport and cities, effective and cheaper aged care and healthcare, better use of our energy resources, to name a few.

The large amount of real-time sensor data streaming from IoT is a challenging issue because of storage capacity, processing power, and data management constraints. Cloud computing is a promising technology to support the scalable storage and processing of the ever-increasing amount of data. There are a variety of books on the market that cover interesting issues related to IoT. However, to my knowledge, only this book provides a comprehensive overview of the transformation of IoT into services. This book takes a unique approach to integrating sensor-based things (IoT sensors), cloud computing, and service-oriented computing. Such sensor cloud services provide unique capabilities and opportunities for efficient and real-time delivery of IoT services to end users. This book is the first attempt of its kind to provide a holistic view of the issues related to the services in a sensor cloud environment by taking into account the spatio-temporal related challenges. The book provides a detailed treatise of spatio-temporal selection and composition of sensor cloud services. One interesting part of this book is the exploration of crowdsourcing as the vehicle to sense data. The specific and important issues related to crowdsourcing of services in sensor cloud environments are addressed. The book overviews key findings from the authors' experience in analyzing a large number of real-world sensor cloud services. The extensive references included in this book will help the interested readers find out more information on the discussed topics.

It is a real pleasure to have been asked to provide the foreword for this book. I am happy to commend the authors for their outstanding accomplishment, and to inform the readers that they are looking at a true state of the art in the vibrant and rapidly expanding field of IoT services.

Macquarie University
Sydney, NSW, Australia
February 2018

Michael Sheng

Preface

The ubiquity of mobile devices has elicited the emergence of the important domain of crowdsourced sensor cloud services. In this framework, the cloud provides the ideal solution for storing, processing, and managing continuous streams of crowdsourced sensed data. We propose to harness the service paradigms, a key mechanism to transform crowdsourced raw data into useful service-ready information. In our framework, sensors are fixed or crowdsourced and provide streaming sensor data which is stored and managed in the cloud. Services are the abstraction through which this data is transformed to suit users' needs (functional) and requirements/expectations (non-functional, also called Quality of Service (QoS)). The combination of functional and non-functional aspects provide the abstraction of a service that represents crowdsourced sensor cloud services.

In this book, we design and develop a crowdsourced sensor cloud framework with special emphasis on spatio-temporal service selection and composition. We propose a new, two-level composition model for crowdsourced sensor cloud services based on dynamic features including spatio-temporal aspects. The proposed approach is based on a formal sensor cloud service model that abstracts the functional and non-functional aspects of sensor data in the cloud in terms of spatio-temporal features. A spatio-temporal indexing technique is proposed that is based on the 3D R-tree, enabling fast identification of appropriate sensor cloud services. Our novel quality model considers dynamic features of sensors to select and compose sensor cloud services. This model introduces a new QoS as a service which is formulated as a composition of crowdsourced sensor cloud services. We present new QoS-aware spatio-temporal composition algorithms to select the optimal composition plan. We present a heuristic failure-proof service composition algorithm for real-time reaction to sensor cloud services which become unavailable because they are no longer spatially or temporally available. We also provide a greedy redistribution algorithm that offers incentives to crowdsourced service providers to achieve optimal balanced crowdsourced coverage within an area.

We have evaluated the performance and effectiveness of the proposed framework. The experimental results show that the proposed composition framework and incentive-based approach have a satisfying scalability as the number of services becomes larger.

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Azadeh Ghari Neiat

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Athman Bouguettaya

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