Offloading Cyber-Physical Tasks using Mobile Crowdsourcing

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ABSTRACT

Recent generations of mobile phones, embedding a wide variety of sensors, have fostered the development of open sensing applications, such as network quality or weather forecast applications. Nonetheless, critical non-functional concerns like the energy consumption or the user privacy remain poorly covered by such dedicated applications, incidentally impacting the user experience. In this paper, we introduce APISENSE as a distributed middleware platform that leverages the dynamic deployment of crowdsourcing tasks across a population of mobile phones. We illustrate the originality of APISENSE on a mobile crowdsourcing experiment operated by human and social science scientists: PRACTIC.

Keywords

crowd-sensing, mobile crowdsourcing

1. INTRODUCTION

The continuous growth of mobile devices has raised the opportunity to easily connect to a crowd of mobile users to engage them in the completion of a variety of cyber-physical tasks. In particular, mobile crowdsourcing (or crowd-sensing) refers to the capability of lifting a (large) diffuse group of participants to delegate the task of retrieving trustable data from the field. Beyond crowdsourcing, crowd-sensing can blend human and machine computations by taking benefit of the sensors and interfaces that are embedded into the latest generation of smartphones [3].

In this paper, we introduce APISENSE, a mobile crowdsourcing platform that makes easier the deployment of crowd-sensing experiment by taking care of the critical challenges in this area [1]. While the development of crowd-sensing applications has been leveraged by the availability of open sensing frameworks like Open Data Kit[1] or the Funf Open Sensing Framework[2], critical issues like the energy consumption, user privacy, user incentive and recruitment remain insufficiently covered by the state of the art.

The novelty of APISENSE is therefore to provide a *Software-as-a-Service* platform to describe crowd-sensing experiments as scripts, which will be offloaded onto mobile devices in order to collect data on the field. APISENSE covers both participative and opportunistic data collection: While participative experiments involve the end-user in the production of datasets (*e.g.*, by filling out a survey, by taking a picture), opportunistic experiments are rather seamless and automatically trigger the mobile phone sensors to collect the requested data.

In the remainder of the paper, we first describe the key challenges to be addressed in the area of crowd-sensing (cf. Section 2). We then provide an overview of the APISENSE platform (cf. Section 3) and the PRACTIC initiative (cf. Section 4) as an example of mobile crowdsourcing experiment that blends both participative and opportunistic modalities, before concluding (cf. Section 5).

2. CROWD-SENSING CHALLENGES

Mobile crowdsourcing comes with a set of specific challenges that have to be taken into account when developing mobile sensing applications:

Task description refers to the definition of a domain-specific model that can be used to describe a wide diversity of crowdsourcing activities. In particular, this model should provide a natural notation for querying the crowd and storing the dataset;

User recruitment in the area of mobile crowdsourcing is highly dynamic and requires not only to take into account user expertise but also user context (*e.g.*, location, device capabilities, battery level) in order to properly adjust the cyber-physical tasks;

Task orchestration aims at exploiting of the density of users involved in an experiment to reduce the individual cost of data retrieval or to improve the quality of the information. Mobile crowdsourcing should therefore be able to adjust the offloading of tasks to satisfy some crowd-level objectives (*e.g.*, ensure a critical volume of data);

User privacy is a critical challenge, which requires a careful consideration of the implications of collecting user sensitive information like its current location. This implies the development of various technics to blur such

[1]ODK: `http://opendatakit.org`
[2]Funf: `http://www.funf.org`

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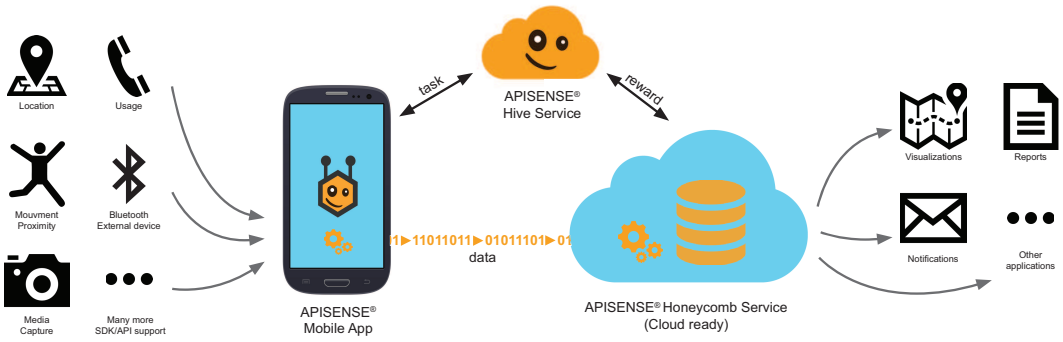

Figure 1: Overview of the APISENSE platform.

sensitive information to avoid discarding unexpected data;

Energy consumption is a technical challenge that covers both device-level optimizations (*e.g.*, location inference) and crowd-level ones (*e.g.*, location sharing) to minimize the energy impact for the mobile users;

User incentives finally group all the aspects related to raising and maintaining the motivation of end users to keep them involved in the experiments and therefore ensure an active participation along time.

3. APISENSE PLATFORM

APISENSE builds on a distributed architecture. In its center sits the Hive service, that is responsible for managing the community of mobile users and publishing crowd-sensing tasks. These crowd-sensing tasks are uploaded on the Hive from Honeycomb endpoints, which are deployed and used by people interested in collecting specific datasets. The Honeycomb is therefore used to describe the crowd-sensing tasks as scripts (based on an extension of JavaScript) that are seamlessly offloaded onto mobile devices by the Hive. Once triggered by the mobile device, these scripts will automatically produce a dataset, which will be sent back to the Honeycomb to be processed and stored depending on experiments (cf. Figure 1).

In APISENSE, the adoption of scripts as a model to describe mobile crowdsourcing tasks drives the way data is stored by the Honeycomb service since datasets collected by mobile devices are JSON documents, which can be automatically stored in NoSQL databases, like MongoDB[3]. One of the benefits of building a common platform like APISENSE lies in the federation of communities of mobile users who are willing to contribute to mobile crowdsourcing experiments in order to ease their recruitment and therefore focus on the nature of the datasets to be collected [1]. The APISENSE platform also implements the concept of *virtual sensors* as a mean to abstract the individual devices and therefore offer a set of additional services that self-organize a group of mobile devices to orchestrate the retrieval of datasets according to different strategies (*e.g.*, round robin, energy-aware). The user privacy crosscuts different components of the platform. First, the architecture of APISENSE prevents the HONEYCOMB endpoints to communicate directly with the mobile user. Then, the software components deployed on the mobile device implement several algorithms to filter out and blur sensitive information (*e.g.*, address book, location) depending on user preferences. The user keeps the control of her mobile phone to select the sensors to be shared, as well as when and where these sensors can be used by the platform. Finally, the APISENSE platform supports the implementation of different incentive strategies, including user feedback, user ranking, user rewarding and win-win services [2]. The selection of incentive strategies carefully depends on the nature of the crowdsourcing experiments.

[3]MongoDB: `http://www.mongodb.org`

4. PRACTIC EXPERIMENT

The APISENSE platform has already been used to deploy mobile crowdsourcing tasks for analyzing the quality of access to the Internet and studying the mobility models in urban areas. More recently, as part of the MetroScope consortium[4], the PRACTIC experiment used APISENSE to deploy social sciences crowdsourcing tasks to analyze usage patterns of hundred of mobile devices over a month[5].

5. CONCLUSION

This paper reported on the challenges of raising a crowd of mobile users to fulfill crowdsourcing tasks using their own smartphone. To address this challenge, we introduce APISENSE as an open platform that can be used to quickly deploy a wide diversity of crowdsourcing tasks with some guarantees in terms of energy consumption and user privacy. This platform is already used by various academic and industrial sensing applications to continuously collect meaningful datasets with or without the explicit participation of end users.
APISENSE is available online: `http://www.apisense.com`.

6. REFERENCES

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[4]MetroScope: `http://www.metroscope.eu`
[5]PRACTIC: `http://beta.apisense.fr/practic`