Poster Abstract: Towards Crowd-aware Sensing Platform for Metropolitan Environments

Saumay Pushp[1], Chulhong Min[1], Youngki Lee[1], Chi Harold Liu[2], Junehwa Song[1]

[1]Department of Computer Science, KAIST
Daejeon, 305-701, Republic of Korea
{saumay, chulhong, youngki, junesong}@nclab.kaist.ac.kr

[2]IBM Research
Beijing, 100193, China
chiliu@cn.ibm.com

ABSTRACT

In this paper, we propose an *in-situ Crowd-aware Sensing Platform,* called *"CrowdMon",* which envisions the cooperation among mobile users in highly crowded urban areas such as metro and square. CrowdMon establishes a spontaneous connection from co-located users in a *semantic proximity* and enables them to share contextual information such as location, ambient music, and mood of places. To the best of our knowledge, CrowdMon is the first attempt to support crowd-aware services at a platform level. We show interesting use cases of CrowdMon and an initial system design to realize the crowd-based context sharing.

Categories and Subject Descriptors

K.8 [Personal Computing]: General; C.3 [Special-Purpose and Application-based Systems]: Real-time and embedded systems

General Terms

Design, Management.

Keywords

Crowd, Context, Sensing, CrowdMon.

1. INTRODUCTION

In a metropolitan city, people often spend their daily urban lives together in diverse places such as downtown, squares, stadium, metro, and bus. Such crowded situations provide a new opportunity in harnessing ubiquity of smartphones around mobile users and provide life-immersive services ascertaining users' situational contexts, one such proposed approach leverages cloud enabled mobile sensing which analyzes different user's activity/environmental state pertaining to given contextual requirements [4]. Also, smartphones can easily share contexts and computational resources and thus achieve resource savings [2]. However, such opportunities have been rarely leveraged in most existing personal mobile sensing systems.

We show two scenarios which potentially and significantly benefit from our proposed platform.

Figure 1. An example of crowd sensing scenario potentially full of opportunistic participatory activities (e.g. live video sharing and neighborhood gaming).

Scenario 1: while traveling Canada, Sam joins the Toronto's festival of beer where more than 100 vendors and 35,000 beer enthusiasts participate (see Figure 1). When he reaches the main stage where various live acts are being performed, he figures out the place, already crowded with visitors and that he has no choice but to see the concert from a long distance. Then CrowdMon establishes a spontaneous crowd network and enables him to watch the scene with live video captured by visitors who have better views of the concert.

Scenario 2: John loves traveling and wants to keep detailed memory about his travel. Thus, while traveling, he likes to use a mobile application, *TripRecorder* that tracks users' path and logs surrounding events extracted from ambient sound. Despite its usefulness, John sometimes hesitates to use the application as it consumes huge amount of battery power for GPS sensing and CPU cycles for sound processing. In this case, CrowdMon can mitigate this problem quite significantly, especially when he travels in some highly crowded urban areas. For instance, while he is moving to a travel site on a bus, he can obtain and record location information from any other passengers on the bus.

Recent study [3] have investigated the mobility pattern among mobile users and argued about achieving context sharing in crowd situations. Furthermore, [2] utilizes friendship ties among users and additionally considers the fact that they are always together given a particular situation. But as such, no platform exists to fully exploit daily life patterns and provides ubiquitous context sharing at runtime.

Realizing CrowdMon involves multilateral challenges. Most importantly, the composition of spontaneous crowd network is very difficult due to high user mobility, flexible network boundary, multiple ownership, and heterogeneity of member devices. Considering these difficulties, one big question would be how to figure out users who may offer some desired context in a most stable manner; e.g., users in the same *surrounding context* may face more computational and battery resources if they can't figure out a potentially beneficial cooperator. In such case they should intelligently use their own battery resource (considering the non-favorable sharing environment).

Besides the crowd composition, CrowdMon aims to provide a unified programming interface for multiple dynamic devices that specifies crowd-aware service queries. CrowdMon will provide crowd-aware applications with intuitive APIs with respect to different contexts in a query declarative manner [1]. Also, it is essential to protect the privacy, as CrowdMon conducts itself through a large scale collaborative sensing which not only includes the friend circle but also the ones we encounter in our everyday life. To address this, we provide an access controller which deals with different levels of context sharing; depending upon certain level of interaction which is achieved during various encounters (e.g. how often a person meets someone in his everyday life and definitely this would give a *preference level* regarding future sharing).

We propose a novel crowd-aware sensing platform which not only provides context sharing among those who come across frequently in our daily life (different situations and locations) but also performs potential proximate user selection on the run. To figure out the potential proximate users, CrowdMon monitors the period of user availability at a given place. It stores this information to provide or attain any opportunistic contextual information in case of next encounter (the information stored is the one acquired at runtime).

2. ARCHITECTURE

We designed the architecture of CrowdMon as shown in Figure 2. It runs as a middleware on the top of Android OS. It will use registered queries by leveraging cooperation opportunities with nearby users. It handles the query with the user's own devices if it finds no potentially beneficial cooperator. For the crowd composition and the application services, we consider the quality of service, which usually vary due to heterogeneity of ambience noise or users' activity that may affect the quality of monitored context.

Connection Manager plays an essential role to compose the spontaneous crowd network for the purpose of the service. It first discovers nearby potential collaborators for crowd composition, by leveraging either Bluetooth or WiFi-Direct. This is done by accounting peers availability under a given periphery [5], which changes periodically from place and its context. *User's Activity Profiler* measures the potential of its user, as if he/she should behave as a stable user to share any sort of context or should search for one, to attain some contextual information. *Information Disseminator* is in charge of channelizing different query/response as per user's need. *Task Allocator* maintains

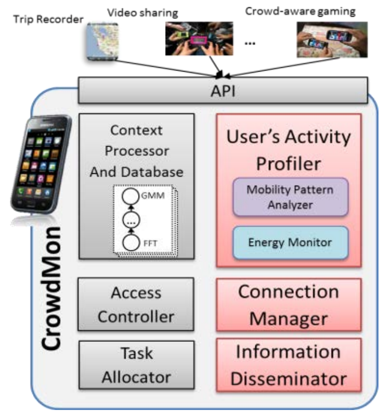

Figure 2. Proposed CrowdMon architecture.

the network connection and allocates adequate tasks in a distributed manner, depending upon the query result, i.e., whether switching to Wi-Fi or Bluetooth depends upon the strength of signal it needs. According to the cooperation plan, the *context processor* on the smartphone continuously processes the requests and delivers the processing results to the applications. It incorporates a variety of processing modules for sensing, feature extraction, and context classification to support diverse types of contexts as well as performs all database related operations. For the privacy, *Access Controller* monitors the degree of contexts, trust, and privacy which further result in achieving certain level of cooperation among different users.

3. REFERENCES

[1] Y. Lee, S.S. Iyengar, C. Min, Y. Ju, S. Kang, T. Park, J. Lee, Y. Rhee, and J. Song. "MobiCon: Mobile Context-Monitoring Platform," in *Communications of the ACM (CACM), March'12.*

[2] Y. Lee, Y. Ju, C. Min, S. Kang, I. Hwang, and J. Song. "CoMon: Cooperative Ambience Monitoring Platform with Continuity and Benefits Awareness", in *ACM MobiSys'*12.

[3] R. Wu, Y. Cao, C. H. Liu, P. Hui, L. Li, and E. Liu. "Exploring Passenger Dynamics and Connectivities in Beijing Underground via Bluetooth Networks," in *Int'l Workshop on Internet-of-Things Comm. and Netw. (IoT-CN, in conjunction with IEEE WCNC'12).*

[4] S. Sen, A. Mishra, R. Balan, and L. Lim. "The case for Cloud-Enabled Mobile Sensing Services," in *MCC'12 (ACM SIGCOMM'12 Workshop).*

[5] S. Pushp, T. H. Cho, J. Han, D. Lee, J. Song, and S. Choi. "An Efficient way to Track Peers in Mobile P2P Network," in *ACM MobiCom'12 (Extended Abstract).*