Mobile Sensing for Social Collaborations

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ABSTRACT

In this paper, we present three interesting ongoing and future research projects on the topics of mobile collaborative sensing, namely: (a) efficient network management for context-aware participatory sensing, (b) 3D mobile collaborations, and (c) opportunistic social collaborations. The proposed concepts, models, and solutions could be largely beneficial in the developing world, by using the mushroom popularity of the smartphones and online social networks. We address their technical challenges and solutions from the support of the information quality and efficient network management perspectives. The main objective of this paper is to receive early feedback from researchers and practitioners in the areas of mobile computing and social collaboration, and to brainstorm and synergy new collaboration opportunities.

1. INTRODUCTION

The past several years have seen the astounding proliferation of affordable, wireless, and easily programmable mobile computing and communication devices such as smartphones [3]. While integrated media and location-tracking features (e.g., cameras, GPS receivers, accelerometers, etc.) have become standard fare, one can expect a rapid increase of other "sentient" functions via additional integrated or peripheral environmental sensors; examples include sensors for measuring pollen, air-pollutants, humidity, etc. Overall, these advancements are bringing forth the "mobile collaborative sensing" model, in which users, or participants, use personal mobile computing devices to collaboratively collect, possibly analyze, and make available nearby environmental data for large-scale applications.

Collaborative sensing could potentially be further largely enriched by using the information from online social networks, like Facebook and Twitter, to compliment their current *location*-aware mobile sensing units by adding the *preferences* and *relationships* elements, both unobtrusively and in real-time. The integrated use of these elements further enhance the learning and inference of a group's tastes, and thus enable mobile users to share the information among friends on the move.

We notice that as the price of smartphones become more affordable, more people in the developing world are now be able to access the outside world and share information, which would cause fundamental changes of their living and communication styles. Also, the Internet has been widely popular and used (like in Asia 21.5% of the population can assess the Internet with the growth rate of 621.8% last year [1]), and online social networks have been adopted in different languages and communities, available for use at any age. Therefore, these assets in the developing world make new deployment easily reach a certain user mass, and the fundamental elements supporting new application scenarios are already ready.

To this end, in this position paper we present three ongoing and future research projects within the context of the mobile sensing for social collaborations. The proposed models and solutions address the technical challenges from the support of information quality and the network management aspects. These concepts largely extend the *primitive* intelligence available among mobile devices investigated so far, to the case where context-aware interactions and collaborations among users and their interest groups are largely allowed. Application scenarios for our ongoing project of "participatory sensing" include to provide remote, real-time monitoring and control of farming operations among farmers, or perform manufacturing control in the factory, and to enable mobile users to post and work on sensor-related crowdsourcing tasks, like geolocation-aware image collection and tagging, road traffic monitoring, etc. The proposed "3D mobile collaboration" concept could be a best fit for family and friends-based activities; and the "opportunistic social collaboration" concept targets a mass of community even among strangers to share streaming media on the move. Finally, we note that the developing world is just used as an example but our application scenarios can extend to the developed world as well.

2. ONGOING PROJECT

Our ongoing research project, "Efficient Network Management for Context-Aware Participatory Sensing", partly funded by the Thin Sense Project of Deutsche Telekom Laboratories[1], is developed on the basis of the smartphone-based

[1] An invited paper will appear at IEEE IQ2S Workshop 2011, and the other paper is under review at IEEE SECON 2011.

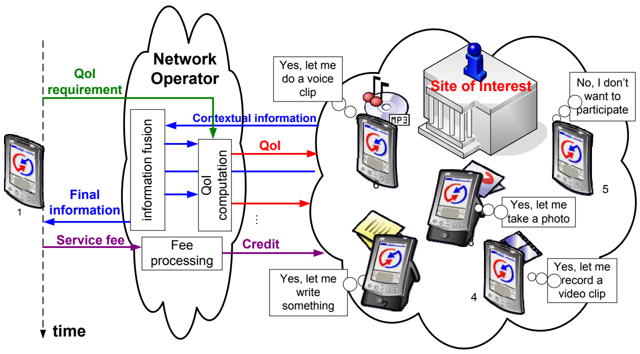

Figure 1: Example of participatory sensing, where user 1's request is directed to a set of users labeled as 2-6 within the proximity. Some users decide to participate via contributing certain type of contextual information, for example, text message, voice clip, image, and video, while others may not.

micro-blogging system [2]. Fig. 1 shows a population of mobile device users subscribing to a wireless service provider (or *network operator*) and a user (or *querier*) of a participatory sensing application offered by the network operator. The querier asks the application for some information about a landmark, such as the size and location of crowds near a tourist site. The application then forwards the query to the mobile users near the site. Upon receiving the query, users decide whether they will respond and send data back to the application, where data processing may occur before a result is returned to the querier. The users who supplied data would receive some form of credit from the service provider as a reward for supporting the efficacy of the application.

Supporting application scenarios such as the one above requires addressing the following challenge: *balancing the quality of information (QoI) produced by the system with its energy-efficiency, while providing satisfactory benefits to the querier, network operator, and participants.* While the problem above also exists for traditional sensor networks, it is compounded in the participatory sensing context for multiple reasons. First, as opposed to traditional sensor "motes," smartphones (and the like) are not dedicated sensor devices and have competing *traditional* demands for energy resources (e.g., voice calls, text messages, and gaming). Second, smartphones are *personal* devices upon which any outside party cannot expect to impose traditional sensor network energy management mechanisms such as duty cycling and power state control; only the device's user can control energy usage. However, as described in the earlier application scenario, incentive-based techniques may be used to influence energy usage on personal devices and furthermore, help balance QoI and energy-efficiency. These challenges and general approach serve as the basis for our work.

In our earlier publications, we have proposed a novel QoI-aware energy-efficient network management framework for participatory sensing. Our solution approaches the problem from two angles, the first being that of the network operator. Here, the goal is to maximize the QoI of the system by maximizing the participation of mobile device users, while minimizing the cost of doing so, via minimizing the credits granted for participation. We model this as a constrained optimization problem and quantify the QoI benefit that queriers receive in relation to the level of QoI they re-

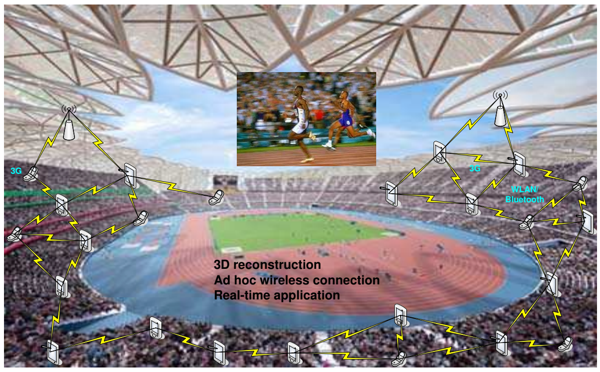

Figure 2: An illustrative example for the proposed Games-oriented networking for 3D scene reconstruction in realtime.

quest as the *QoI satisfaction index*. The second angle of our approach relates to the mobile device user. Here, we propose a distributed scheme for deciding both the device's energy consumption state and the quality of data to contribute to the application. For this, we employ the mathematical framework of the Gur Game [4], where notions of reward and punishment, represented by credits and energy loss respectively, locally guide the balance between QoI and energy-efficiency.

3. FUTURE PROJECTS

3.1 3D Mobile Collaborations

The key idea of the 3D mobile collaborations is to offer 3D real-time experience among a mass of audiences for a public event, like Olympics, at anytime, wherever they are seated, as shown in Figure 2. The network will be established as soon as audiences sharing common interests request the service, and photos/videos from those phone cameras will be fused for real-time 3D reconstruction and delivered back to the individual audience, so that they could potentially benefit from views in different angles around the stadium. The real-time feature will completely shape the conventional thinking of watching events in such a way that 3D scene reconstruction provides an important complementary view for all audiences anytime anywhere for anything.

We have identified two important features. First is that the network forms and vanishes automatically, completely relied on the audiences' needs, i.e., the 3D experience can be provided on demand, after which network resources would be released immediately. Second is that compared with traditional TV recording, the proposed solution does not need to record every second of the event, deliver back to media center for processing, and broadcast to all audiences at all times. Instead, the on-demand 3D processing will be performed *in the air*. The applicability of such networks could be anywhere as long as there is a scene with large number of participants. The exemplary scenarios include but not limited to Olympics, Premium League, theater shows, concerts, etc., to improve the constrained views for all audiences anytime, anywhere.

3.2 Opportunistic Social Collaborations

Since the data from social networks would add another dimension of the preference and relationship-aware informa-

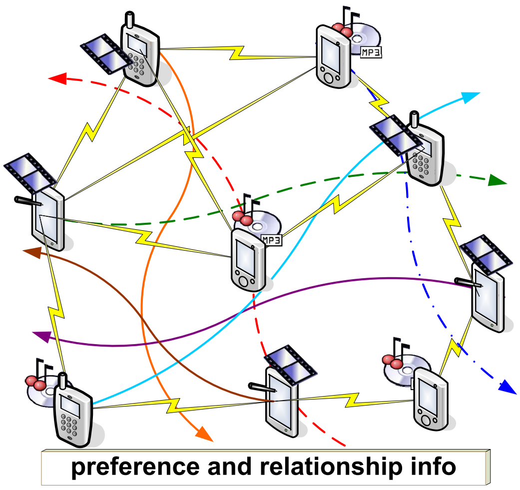

Figure 3: An illustrative example of using mobiles to opportunistically share information among friends on the move.

tion, we propose the concept of the "opportunistic social collaborations", as any distributed system that combines the social network with mobile sensing in a collaborative way. Figure 3 shows an illustrative example. Different from the existing mobile social networks, our target scenarios are the busy shopping mall, book shops, or even buses and underground trains, where people holding the mobile phones moving around the area and *opportunistically* share their preferred music and video clips with the *walking-by* neighbors, if the latter are identified as friends or simply sharing common interests. Therefore, the connectivity and information of a particular individual are not limited by themselves, but rather extended to a larger range of the community through the collaborative mobile users and their associated social information.

4. AUTHOR BACKGROUND

The authors of this paper have been closely working together, and also aiming to continue their collaborations to vividly investigate the previous mentioned research projects. A short biography of each could be found as follows.

4.1 Dr. Chi Harold Liu

Dr. Chi Harold Liu is a staff researcher with the Department of Networked Computing at IBM Research - China. He holds a PhD degree from Imperial College, U.K., and a BEng degree from Tsinghua University, China. Before joining IBM Research - China, he worked as a PostDoc researcher at Deustsche Telekom AG in Berlin, Germany, where he was involved in the GlobalSense and ThinSense projects on social networks and collaborative sensing. He also has been involved in EU-FP6 MEMBERANE Project, and the US Army-UK MoD co-funded ITA Project on sensor and mesh networks. In 2009, he was a research intern at IBM's T. J. Watson Research Center in Hawthorne, USA. His current research interests include the Internet of Things (IoT), context-aware computing, and protocol designs for ad-hoc, sensor and mesh networks. He has published more than 30 prestigious conference and journal papers, technical reports, and project deliverables. He also has served as the TPC and the Industry Chair of PESARO 2011. He is a member of IEEE.

4.2 Dr. Pan Hui

Dr. Pan Hui is a senior research scientist in Deutsche Telekom AG Laboratories Berlin. He received his PhD from Computer Laboratory, University of Cambridge. During his PhD, he also affiliated with Intel Research Cambridge. Before that he was with University of Hong Kong for his MPhil and bachelor degree. Dr. Hui is an expert in communication for developing areas, more particularly in delay tolerant networking (DTN) and mobile computing. He has published many seminar papers in the area and has been invited to delivery keynote speeches in several related workshops. Dr. Hui has co-founded three workshops on areas related to computing for developing regions including ACM HotPlanet, SIMPLEX and ExtremeCom. He also co-chairs the ACM Mobicom Workshop on Challenged Networks (CHANTS 2010) and has served on the program committee of several conferences and workshops, including Infocom and Globecom.

His past organized ACM ExtremeCom 2009 workshop was the first of its kind in bringing the researchers into the environment where they designed the systems for challenged communication. The workshop was arranged in a remote area of the Swedish mountain and included a four-day hiking as well as paper presentations and technical discussions. Participants experienced the target environment for challenged communication and discussed with intended end users. The workshop was a huge success and all participants found the attendance highly rewarding. Based on the success of the workshop, a second edition, ExtremeCom 2010, was organized in the mountain area of Dharamsala in northern India.

5. CONCLUDING REMARKS

In this paper, we presented three interesting ongoing and future research projects, i.e., efficient network management for context-aware participatory sensing, 3D mobile collaborations, and opportunistic social collaborations. We have identified that these topics are closely related to the topics of mobile collaboration in the developing world, and their connections even outside the developing world. We also address their fundamental technical challenges and some of the solutions, followed by the biographies of the authors. We are happy to receive early feedbacks from the research community and participants of this workshop, and potentially build up new connections and collaboration opportunities with them to tackle some of the issues presented in this position paper.

6. REFERENCES

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