Energy-efficient Tasking in Participatory Sensing Systems

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Abstract

By leveraging sensors embedded in mobile devices, participatory sensing tries to create large-scale sensing systems. One major challenge in these participatory sensing networks is the problem of distributing sensing tasks in an energy-efficient manner. A large portion of energy is typically consumed for the exchange of tasks between the tasking server and the mobile devices, as well as for the position monitoring needed to detect whether a user is situated within the tasking area. In this paper, we mainly focus on reducing energy for receiving and monitoring tasks on the client side. We propose an energy-efficient task distribution and monitoring concept for participatory sensing system and evaluate it by means of simulation.

Keywords: *tasking, energy-efficiency, participatory sensing*

1. Background

Recent mobile phones include an increasing set of embedded sensors. Currently available phones come with built-in accelerometers, gyros, location, audio, and image sensors. With this development mobile phones evolve from standard phones, intended for personal communication only, to ubiquitous sensing devices that are globally distributed. These devices could be applied to form a new kind of sensor network, so-called participatory sensing networks (PSN) (also referred to as *mobile phone sensing* [1], *people-centric sensing networks* [2] or *mobile crowdsensing* [3]), where people serve as carriers for mobile phone-based sensors. PSNs allow for large-scale global data collection and real-time information display. They could be used, for instance, to monitor environmental pollution, temperature, or noise intensity of urban areas. Even though PSNs are related to wireless sensor networks (WSN), there are significant differences between those two types of sensor networks (cf. [4] The main advantage of PSNs is that data can be collected on a large-scale with automatically deployed, consumer-paid sensor nodes.

2. Problem Definition

The sensing process in PSNs can be with or without the user's intervention, often referred to as participatory and opportunistic sensing respectively (cf. [5]). For instance, taking a photo at a specified place typically requires human intervention, whereas continuously recording the noise level could also be done automatically. In either case, the mobile phone needs to receive information about where and what to sense, i.e., the tasks it should process. We assume that tasking requests r are tuples of the form $< i, a, c, d >$, where i denotes the type of information that should be collected (e.g., noise level),a describes the area in which the information should be collected, c is the desired coverage count (i.e., the amount of users that should process this task), and d denotes the date until the task request is valid. Furthermore, we assume that tasks can be created by users whenever they want, and are removed, if either d has been passed or c has been reached. This leads to a continuously changing set of active tasking requests R.

During the completion of tasks, the device's energy is consumed at the following stages:

- *Receiving tasking requests*: At first, the client needs to receive the tasking requests it should process. Energy is either needed for actively downloading task lists or receiving push notifications by the tasking server.
- *Monitoring tasks*: Upon receipt of the tasks, the client needs to monitor whether it is situated within the tasking area a or not.Here, most energy is consumed by the localization procedure, e.g., GPS positioning.
- *Processing tasks*: If a client is located within a tasking area of a task $r \in R$, the task should be processed, i.e., the sensor information $r[i]$ should be collected.In this step, the consumed energy results from the sensing process itself.
- *Submitting task results*: In the last step, energy is consumed for the transmission of the task results to the tasking server.

The energy consumed in the third stage is strongly dependent on the type of information i, hence an application-specific optimization is most-suitable.

3. Approach

In this paper, we mainly focus on reducing energy in the first two stages. More precisely, as localization is the most energy consuming part in this process, our primary focus is to reduce the amount of localization cycles (i.e., GPS fixes). Further, we want to reduce the amount of communication between the client and the tasking server. Both, however, without losing the effectiveness of the PSNs, i.e., without clients missing out on tasks they could have processed.

Therefore, we present our energy-efficient task distribution and monitoring concept for participatory sensing system, which is based on three major features: (1) GSM Cell-based Task Distribution; (2) Adaptive Monitoring with Movement Detection; and (3) Task Bundling. We describe the realization of these features and evaluate our concept by means of simulation, using the JiST/SWANS simulator [6].

4. References

[1] N. Lane, E. Miluzzo, H. Lu, D. Peebles, T. Choudhury, and A. Campbell, “A survey of mobile phone sensing,” IEEE Communications, vol. 48/9, pp. 140–150, 2010.

[2] A. T. Campbell, S. B. Eisenman, N. D. Lane, E. Miluzzo, R. A. Peterson, H. Lu, X. Zheng, M. Musolesi, K. Fodor, and G.-S. Ahn, “The Rise of People-Centric Sensing,” IEEE Internet Computing, vol. 12, pp. 12–21, 2008.

[3] R. Ganti, F. Ye, and H. Lei, “Mobile crowdsensing: current state and future challenges,” IEEE Communications, vol. 49/11, pp. 32 –39, 2011.

[4] K. Wiesner, M. Dürr, and M. Duchon, “Private Pooling: A Privacy-Preserving Approach for Mobile Collaborative Sensing,” in Proceedingsof 3rd International ICST Conference on Security and Privacy in Mobile Information and Communication Systems (MOBISEC 2011), Aalborg, Denmark, 17-19 May 2011.

[5] N. D. Lane, S. B. Eisenman, M. Musolesi, E. Miluzzo, and A. T. Campbell, “Urban sensing systems: opportunistic or participatory?” in Proceedings of the 9th Workshop on Mobile Computing Systems and Applications, ser. HotMobile ’08. New York, NY, USA: ACM, 2008, pp. 11–16. [Online]. Available: http://doi.acm.org/10.1145/1411759.1411763

[6] “JiST / SWANS: Java in Simulation Time / Scalable Wireless Ad hoc Network Simulator - v1.0.6,” http://jist.ece.cornell.edu/, March 2005.