Context-aware Resource Sharing for People-centric Sensing

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I. People-centric Sensing

In order to tackle the problem of climate change we crucially need to develop a sustainable society. This requires everyone to become aware of the precariousness of the situation, while at the same time a major scientific effort is needed. A core issue standing in the way of sustainability is that of environmental pollution. People-centric sensing is an increasingly popular approach for monitoring pollution in urban environments [5]. This model relies on mobile computing devices to enable ordinary citizens to assess their exposure to pollution factors in their everyday activities. A such, this sensing approach yields individualised data with a higher spatio-temporal granularity than systems based on sparse and stationary sensors [9], while the active involvement of citizens in the monitoring increases their awareness of environmental issues. However, people-centric sensing is hampered by the still limited capacities of current mobile devices, in terms of processing power and battery autonomy as well as the absence of specialised environmental sensors [3], limiting participation to those who have access to expensive or adapted devices.

Our claim is that in an approach like people-centric sensing, where the participation of the people directly impacts the quality and quantity of the data collected, such restrictions should be alleviated. Indeed, given the urgency of the environmental challenges we face, we cannot wait for new generations of mobile devices to provide better hardware and software capacities, and become affordable for the public at large.

II. Context-aware Resource Sharing

In this work, we explore an extension to people-centric sensing that enables people to share and use resources available in range, in an opportunistic way [6]. The sensing process in this case is no longer constrained by the capacities of specific mobile devices, but instead can be distributed among the available resources (e.g. other mobile devices, sensors or indoor/outdoor appliances). Data gathering, processing and publishing can then be accomplished by resources that are dynamically discovered and selected according to their suitability, availability, and user preferences. We consider a people-centric environmental monitoring network along the lines of [10], where mobile phones are used to obtain information about user's individual exposure to pollution (e.g. air quality, noise and micro climate), after which it is sent to specialised servers for further processing. A people-centric sensing model that supports resource sharing would enable to use nearby functionality that complements one's own device:

- by relying on nearby mobile phones for additional processing power or for obtaining missing data such as GPS coordinates;
- by using sensors embedded in buildings, cars or on public transport, or put in any place of interest;
- by publishing the data to servers in a transparent way, by delegating the task to devices that do have Internet connectivity when necessary.

Sharing resources multiplies the possibilities for sensing to be performed. But it also inherits problems of opportunistic collaborations such as zero infrastructure, volatile connections, and platform heterogeneity [13], [8]. At the VUB university we have developed a number of models to cope with these issues in the context of ambient intelligence [2]. Also, in a collaboration between Sony CSL Paris and the VUB, we have developed a people-centric sensing framework for noise pollution monitoring called *NoiseTube* [10]. Our proposal is to combine these two efforts in what we call a *context-aware resource sharing model for people-centric sensing.*

III. Our Experience

NoiseTube. The NoiseTube project provides a participatory approach [4] to the monitoring and mapping of noise pollution. It enables citizens to measure their personal exposure to noise by using GPS-equipped mobile phones as noise sensors. This quantitative data may be further augmented by qualitative data under the form of *tags* [11], open-ended keywords derived automatically (location, time) or entered by the users (subjective experience). The system allows participants to share data though a website [1] in order to facilitate collective monitoring initiatives.

Context-aware languages. At the VUB, we have defined an event-driven programming language model to enable context-aware service collaborations on opportunistic, ad-hoc networks, like the ones required in this paper. This model, implemented in our artefacts AmbientTalk [13] and Lambic [12], relies on a decentralised service discovery mechanism, non-blocking communication with explicit support for network failures, and runtime behavioural adaptations. Resource sharing for people-centric sensing has been tackled in architectures like MetroSense [6]. We claim that a language level solution allows the developers to focus on the sensing process by abstracting away accidental complexity.

Case Study. We are currently working on a case study in the Brussels Region and on generalisations of NoiseTube for studying atmospheric pollution and urban microclimates [7]. Certainly for the latter, issues of resource sharing are crucial, as current mobile phones do not offer integrated pollution sensors. For this reason, we expect our ideas to be especially beneficial to these developments.

References

[1] NoiseTube website. http://www.noisetube.net.

[2] Ambient Intelligence: from vision to reality. Technical report, IST Advisory Group, September 2003.

[3] P. M. Aoki, R. J. Honicky, A. Mainwaring, C. Myers, E. Paulos, S. Subramanian, and A. Woodruff. A vehicle for research: using street sweepers to explore the landscape of environmental community action. In *CHI '09: Proceedings of the 27th international conference on Human factors in computing systems (April 4-9, 2009, Boston, MA, USA)*, pages 375–384, New York, NY, USA, 2009. ACM.

[4] J. A. Burke, D. Estrin, M. Hansen, A. Parker, N. Ramanathan, S. Reddy, and M. B. Srivastava. Participatory Sensing. In *World Sensor Web Workshop (WSW06) at ACM SenSys06, October 31, 2006, Boulder, CO, USA*, October 2006.

[5] A. T. Campbell, S. B. Eisenman, N. D. Lane, E. Miluzzo, and R. A. Peterson. People-Centric Urban Sensing. In *WICON '06: Proceedings of the 2nd annual international workshop on Wireless internet*, page 18, New York, NY, USA, 2006. ACM.

[6] A. T. Campbell, N. D. Lane, E. Miluzzo, R. A. Peterson, H. Lu, X. Zheng, M. Musolesi, K. Fodor, S. B. Eisenman, and G.-S. Ahn. The Rise of People-Centric Sensing. *IEEE Internet Computing*, 12(4):12–21, July/August 2008.

[7] E. D'Hondt. Community memories for sustainable urban living. IWOIB project proposal, July 2009.

[8] S. B. Eisenman, N. D. Lane, E. Miluzzo, R. A. Peterson, G. seop Ahn, and A. T. Campbell. Metrosense project: People-centric sensing at scale. In *WSW 2006 – ACM Sensys World Sensor Web Workshop*, 2006.

[9] European Commission Working Group – Assessment of Exposure to Noise (WG-AEN). Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure. Technical report, European Commission, 2006. Position Paper – Final Draft.

[10] N. Maisonneuve, M. Stevens, M. E. Niessen, P. Hanappe, and L. Steels. Citizen Noise Pollution Monitoring. In *dg.o '09: Proceedings of the 10th Annual International Conference on Digital Government Research*, pages 96–103. Digital Government Society of North America / ACM Press, May 2009.

[11] L. Steels and E. Tisseli. Social Tagging in Community Memories. In *Social Information Processing - Papers from the 2008 AAAI Spring Symposium (March 26-28, 2008, Stanford University, CA, USA)*, number Technical Report SS-08-06, pages 98–103. The AAAI Press, Menlo Park, CA, USA, March 2008.

[12] J. Vallejos, P. Costanza, T. Van Cutsem, and W. De Meuter. Reconciling Generic Functions with Actors. In *ACM SIGPLAN International Lisp Conference, Cambridge, MA, USA*, 2009.

[13] T. Van Cutsem, S. Mostinckx, E. Gonzalez Boix, J. Dedecker, and W. De Meuter. AmbientTalk: object-oriented event-driven programming in Mobile Ad hoc Networks. In *Proceedings of the XXVI International Conference of the Chilean Computer Science Society (SCCC 2007)*, pages 3–12. IEEE Computer Society, 2007.