Going Home for Data: In-Home Sensing for e-Science

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Since its inception, environmental e-Science has largely focused on sensing, analyzing, and modeling large-scale natural phenomena (e.g., earthquake, drought, or climate monitoring and prediction). These more traditional e-Science endeavors often entail placing ecological sensors out in the world, e.g., on volcanoes or deep within ocean crevices, to acquire large amounts of otherwise imperceptible data on the scientific target of inquiry. In our work, we are applying similar distributed sensing paradigms not within the ocean or rainforest but rather *in the home*. The home is an important opportunity for environmental e-Science research because of its ecological footprint and of its potential impact on human health. Our goal is to develop unique, highly granular environmental sensors that can track disaggregated end uses of resource consumption and monitor in-home air and water quality at unprecedented levels. These systems rely on advanced signal processing techniques, machine learning algorithms and, increasingly, cloud computing to store and analyze sensor data across homes (e.g., for calibration bootstrapping and to analyze aggregate patterns in the data).

The residential sector accounts for a surprisingly large amount of resource consumption in the US (21% of electricity [4], 21% of natural gas [5], and 26% water consumption [6]). Understanding *how*, *where*, and *when* these resources are used in the home is crucial to the development and evaluation of resource-efficiency policies, conservation programs and new building codes. We have created sensing solutions to track water [1], electricity [2] and gas [3] usage down to the *individual appliance* or *fixture* from a *single installation point*. For example, the HydroSense sensor [1] screws on to a hose bib and automatically tracks water usage at the individual water fixture level (e.g., dishwasher, shower, or kitchen sink). From an e-Science perspective, our sensors have the potential to contribute unprecedented access to the ways in which resources are used in the home. Disaggregated end use consumption data could allow scientists to more accurately assess and prioritize the energy- and water-saving potentials of retrofit or upgrade programs. In addition, water management scientists could better model demand by examining how much water is used in the home vs. in the garden or yard. Finally, disaggregated end use data could fundamentally change how future buildings are designed and constructed as in-home water distribution and energy loads are better understood.

Two critical areas required to enable this home-based e-Science vision beyond the sensing technology itself will be data connectivity and data storage. In the future, a central data repository, common API, and privacy protection methods must be developed to share this data with other scientists.

References

1. Froehlich, J. Larson, E., Campbell, T., Haggerty, C., Fogarty, J., and Patel, S. (2009). HydroSense: Infrastructure-Mediated Single-Point Sensing of Whole-Home Water Activity. Proceedings of UbiComp 2009, Orlando, Florida, USA, September 30th - October 3rd, 2009.
2. Froehlich, J., Larson, E., Gupta, S., Cohn, Reynolds, Patel (2010). Disaggregated End-Use Energy Data for the Smart Grid. *In Submission*.
3. Cohn, G., Gupta, S., Froehlich, J., Larson, E., and Patel, S. (2010). GasSense: Appliance-Level, Single-Point Sensing of Gas Activity in the Home Proceedings of Pervasive 2010, Helsinki, Finland, May 17-20, 2010. Springer-Verlag, Heidelberg, 2010, pp. 265-282
4. US Energy Information Administration (2007), Annual Energy Review, 2007.
5. US Energy Information Administration (2010), Natural Gas Monthly, February 2010.
6. Vickers, A. (2001). Handbook of Water Use and Conservation: Homes, Industries, Businesses. WaterPlow Press; 1st edition, Aug 1, 2001.