Collaborative Research: CRI: Large-Scale Open Sensor Network Testbed for Urban Monitoring

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Wireless sensor networks have the potential to revolutionize the real-time monitoring of critical geographic areas such as cities, ports, refineries, electrical grids, and large government facilities. As a result, there has been a great deal of academic and industrial research in this field. One key factor, however, has greatly limited the development of this field — the daunting logistical challenge of experimenting with thousands of small, battery-powered nodes.

The Harvard-BBN team proposes to eliminate this problem by building a large-scale, urban sensor testbed of 100+ nodes powered by city electricity (streetlights), and then operating it as an open research facility for academic and industrial groups who want to experiment with novel distributed sensing architectures. Modular network nodes will be built and attached them to streetlights for power. (The team has reached preliminary agreement with the city of Cambridge, MA for using their streetlights; see attached letter of support.) These nodes will contain sufficient processing power and memory to handle a wide range of experimental software, plus 802.11 radios to interconnect all the nodes by multi-hop networking across Cambridge to its wireline access points. Each node comes with baseline Harvard / BBN software in flash to provide a robust sensor network architecture including reliable ad hoc networking. Other teams may use their own software, but the baseline remains in flash memory for automatic network restoration if needed.

Intellectual Merit: CitySense is designed to support a broad range of research projects in large-scale sensor networks. We plan to use CitySense as an essential component of projects involving high-level programming models for sensor networks; effective techniques for resource allocation and sharing; and integration of sensor networks with Internet-based information systems. In addition, developing CitySense will push the envelope for sensor network testbeds in a number of directions as described below.

Trying out new sensors: CitySense nodes will come with a basic set of meteorological sensors. In addition, an open architecture will be developed to allow a wide range of sensors to be plugged in; sensor would be connected via powered Ethernet (or USB) with an XML data interface. Groups that wish to experiment with novel sensors can thus try them in their own lab before installing them on a selected set of nodes in the Cambridge city-wide testbed. For example, BU's Multimedia Communications Lab has indicated interest (see attached letter of support).

Phased upgrade path: The proposed testbed exploits the fact that *ad hoc* sensor networks can grow little by little. Deployment plans call for building a small network in Years 1 and 2 (20 nodes), adding second-generation nodes in Year 3 (total 50 nodes), and adding the latest sensors nodes in Year 4 (total 100 nodes). All nodes will be interoperable, but hardware varies by year to take advantage of Moore's Law and better, cheaper 802.11 radios over time.

Broader Impact: CitySense will have significant impact on the development of large-scale wireless sensor network systems, by providing a permanent, extensible, public testbed. We will open CitySense to the broad sensor network research community, allowing external groups to remotely download their software images into all the nodes in the CitySense network, or into a sensor "swath" when multiple groups are sharing the city-wide testbed.

We plan to test CitySense by developing a specific application: monitoring air pollution transport in a dense urban environment. This application has a significant public health impact and will constitute one of the first high-resolution studies of pollution and its effects on the urban population.

Educational Activities: The development of a large-scale sensor network testbed will also benefit teaching and learning of engineering concepts at the graduate, undergraduate, and K-12 levels. We intend to use CitySense as a tool to teach distributed systems concepts at the graduate and undergraduate levels. Together with our unfunded collaborators from the Tufts Center for Engineering Educational Outreach, we plan to develop a curriculum for K-12 in sensor networks that makes complex engineering concepts such as sampling, averages and RF propagation concrete. (See attached letter of support.)