Enabling Pervasive Mobile Sensing

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(i) Background and experience of the participant in this field – The author has a track record of designing and deploying large-scale sensor networks including a 1,000 node network [1] of XSM motes [8] (10,000 were built), a 550+ node network of solar-powered Trio nodes [9], and a 38 node network [16] of AC power meters [14]. Prior work has explored energy metering at multiple scales [6, 14, 15, 16], support for mobile sensing [3, 4], energy tracking [13], secure code dissemination [12], multihop data transport (48-hop) wireless networks [17], and link layer primitives [10] and protocols [5]. The Epic [11] building blocks have enabled over fifty new platforms created by two dozen organizations [2]. The author's work has been commercialized by Aginova, Arch Rock (now Cisco), Crossbow (now Memsic), Moteiv (now Sentilla), Moteware, SonnOnet, and Vectare, and is in use by hundreds of researcher worldwide. The work has also received four best paper awards (Sensys'10 [5], IPSN'10 [19], HotEmNets'10 [20], and IPSN'08 [6]) and has won two design contests (ISLPED'10 [18] and ISLPED'08 [7]).

(ii) Vision of the participant – Micropower mobiscopes, or simply μ-mobiscopes, are an emerging class of sensor networks that will be worn by people and animals, integrated into clothing or accessories, and attached to everyday objects in homes, offices, factories, farmhouses, cars, trucks, trains, or transit [4]. μ-mobiscopes couple low-power wireless sensornet technology with motion sensing electronics and ubiquitous computing usage models. At the hardware level, near nanopower motion sensors, novel energy harvesting techniques, and inexpensive flash storage make low-power, mobile embedded sensing and tagging devices feasible and imminent. At the system level, however, mobility raises new challenges. These systems are constrained like traditional sensornets, but are truly defined by their unpredictable link volatility and variable energy supply. They will allow us to track doctor-patient interactions, track epidemics, remotely monitor patient recovery, track real-world social networks, monitor the operation of railcars and the goods they carry, tune the office environment to those present, and sample air quality across a city. Emerging μ-mobiscopes will have a profound impact on health, safely, energy and the environment, and they will enable many heretofore impossible applications.

(iii) Evidence that pursuing this vision will lead to major advances in the field – Mobility – and the ensuing unpredictable link volatility and variable energy supply – invalidates many assumptions implicit in today's low-power, static sensornets and high-power handheld and vehicular mobiscopes. Micropower mobile sensing will require advances at the platform, link, network, transport, and application layers of the system. New platforms with near nano-power motion sensing, high-density storage, and solar, vibration, thermal, or RF energy harvesters are needed. At the link layer, new link predictors will replace current estimators, multichannel asynchronous neighbor discovery will become essential, neighbor table management and packet retransmission policies will change, anycast communications will be common, and receiver-initiated communications will become essential.

At the network layer, address assignment, zero configuration techniques, peer-to-peer networking, fluid name-address bindings, mobile routing, and host of other issues will emerge and must be addressed at both architectural and implementation levels. At the transport layer, long periods of disconnection will require adopting DTN techniques to the low-power arena; data must be aggregated into bundles, large-scale storage must be integrated into transport layer, bundle fragment caching policy must be established, data naming techniques must be developed, and the application-transport interface revisited. At the application layer, provisioning, service description, discovery and binding, and storage-centric approaches must be explored.

The key challenge will be devising solutions that (i) embrace the many uncertainties that mobility creates, (ii) adapt the workload to the energy supply and network availability, and (iii) maintain the critical activity/power-proportionality of current low-power sensornet designs.

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