ASCENT: Adaptive Self-Configuring sEnsor Network Topologies

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Advances in micro-sensor and radio technology will enable small but smart sensors to be deployed for a wide range of environmental monitoring applications. The low per-node cost will allow these wireless networks of sensors and actuators to be densely distributed. The nodes in these dense networks will coordinate to perform the distributed sensing tasks. Moreover, as described in this work, the nodes can also coordinate to exploit the redundancy provided by high density, so as to extend overall system lifetime. The large number of nodes deployed in these systems will preclude manual configuration, and the environmental dynamics will preclude design-time pre-configuration. Therefore, nodes will have to self-configure to establish a topology that provides communication and sensing coverage under stringent energy constraints. In ASCENT, each node assesses its connectivity and adapts its participation in the multi-hop network topology based on the measured operating region. For instance, a node:

- Signals when it detects high packet loss, requesting additional nodes in the region to join the network in order to relay packets.
- Reduces its duty cycle if it detects high packet losses due to collisions.
- Probes the local communication environment and does not join the multi-hop routing infrastructure until it is "helpful" to do so.

We have done some initial simulations and experiments using our ASCENT distributed algorithm. We have tested the sensor network with no self-configuration -also called the *active case* where the nodes are turn on all the time-, and with ASCENT using a series of performance metrics. Figures 1 and 2 show some of the results obtained. Detail description of the algorithm, analytical analysis, and further simulation and experimental results are not included here due to lack of space but can be found in the URL mentioned above.

There are many lessons we can draw from our preliminary simulation and experimentation. First, ASCENT has the potential for significant reduction of packet loss and increase in energy efficiency. Second, ASCENT mechanisms were responsive and stable under systematically varied conditions. In the near future, we will perform experiments with larger numbers of nodes to further explore the scalability of our algorithms. We will also explore the use of wider area links to detect network partitions. In the longer term, we will explore more generally the limitations of localized algorithms and their relation to global information in the context of self-configurable sensor networks. We will also expand this work to address other modalities beyond communication and sensing coverage, such us, actuation. This work is an initial foray into the design of self-configuring mechanisms for wireless sensor networks. Our distributed sensing network experiments represent a non-trivial exploration of the problem space. Such techniques will find increasing importance as the community seeks ways to exploit the redundancy offered by cheap, widely available micro-sensors, as a way of addressing new dimensions of network performance such as network-lifetime.

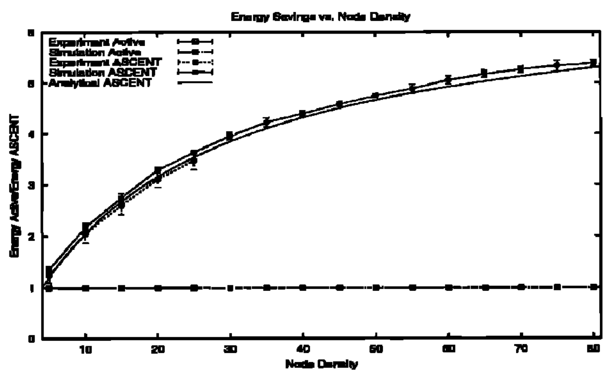

Figure 1. Ratio of energy used by the Active case to the energy used by ASCENT. ASCENT provides significant amount of energy savings over the Active case.

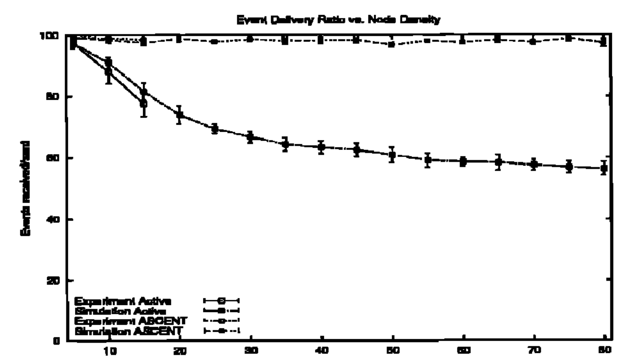

Figure 2. Event delivery ratio as a function of node density. Each packet traverses three hops in the experiments and 6 hops in the simulations. ASCENT delivery rate is stable for the range of densities we tried.