Demo Abstract: Electronic Tripwires for Power-Efficient Surveillance and Target Classification

Tian He, Qiuhua Cao, Liqian Luo, Ting Yan, Lin Gu, John Stankovic, Tarek Abdelzaher
Department of Computer Science, University of Virginia
{tianhe,qc9b,ll4p,ty4k,lg6e,,stankovic,zaher}@cs.virginia.edu

Categories and Subject Descriptors

C.2.1 [**Computer Communication Networks**]: Network Architecture and Design

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1. DEMO DESCRIPTION[1]

This demonstration presents a mini-scale surveillance system developed at the University of Virginia that is currently undergoing a technology transition. The ultimate goal of this project is to develop a clandestinely deployable, environmentally rugged, robust, self-organizing, wireless sensor network for long-term, persistent surveillance, involving detection, tracking, classification, and identification of vehicle and personnel targets over various types of terrain.

One key research challenge for this type of system is to reconcile the need for network longevity (which requires most sensors to remain inactive) with the need for fast and accurate target detection and classification (which requires as many sensors to be awake as possible). In order to reconcile the two conflicting design goals, we developed a suite of services that includes (i) a tripwire-based power management with sentry service, (ii) a radio-based wakeup service, (iii) an entity-based tracking service, and (iv) a three-tier target classification scheme. These services work in conjunction with a localization and time synchronization protocol needed to support their operation.

The conceptual operation of the system is as follows: 1) The sentry service allows most motes to go to sleep, while a small fraction of them (the sentries) remain awake to watch for potential targets. It is ensured that sentries form a communication backbone to deliver important information quickly to long-distance relays in the network when needed. Sentries rotate periodically to balance power consumption.

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2) When a target enters the field, the wakeup service allows a portion of the network near the target to be quickly awakened. Once awake, motes perform target tracking and classification. With the help of localization and time synchronization, the tracking component computes target location and velocity. Classification is done through a three-tier architecture. In essence, at the first tier, sensors differentiate real targets from false alarms and provide different sensing modalities. At the second tier, sensor groups perform data fusion among adjacent nodes that detect the target concurrently. At the third tier, the base node takes current group-level reports as well as history into account to make final classification decisions. This information is sent to a command center through the nearest relay (a device capable of long-distance communication).

3) To scale the system and allow further power savings, a tripwire service can be activated which partitions the field into regions (called tripwires). Individual regions can be de-activated in which case they go to sleep (including their sentries). Active tripwire regions operate as described above, using sentries to look for targets and waking up the remaining nodes only when targets are detected. A target detected by an active tripwire is tracked and classified. Tracking continues across tripwire boundaries waking up nodes on the target's trajectory.

The complete system is designed to scale to at least 1000 XSM motes and cover at least 100,1000 square meters. In this demonstration, a field of 20 - 40 XSM motes is used to form a mini-size sensor network. Two laptops are used as relays. The network is configured into two tripwire regions, each reporting to a different laptop. Active tripwires are shown to perform sentry selection. Sentry nodes identify themselves by showing different colors on the laptop screen (perhaps using a projection device). The remaining nodes go to sleep. Tripwire configuration commands can also be sent if needed to turn off a tripwire for further energy savings. One or a set of (small) targets then enters the field. As the target crosses an active tripwire, the wake-up service is automatically invoked and non-sentry nodes are awakened in the vicinity of the target. These nodes flash their LEDs to indicate active tracking state. Information about the location, speed, and type of the target is promptly sent to the relay(s) and displayed on the screen. The experiment may be repeated with different targets, different configurations of tripwire regions, and different target paths through the network. When the target departs the network and no further activity is detected, nodes go back to sleep leaving only sentries (in active tripwires) to keep watch. After a period of continued inactivity, sentries are shown to rotate to balance power. Re-introduction of targets at any time repeats the wakeup and tracking scenario described above.