ABSTRACT
Design and prototyping are underway for realization of a concept called community sensor grids. The idea is that individuals or small community agencies may deploy sensors to cover their own property, but also make them available for private as well as public monitoring through Internet connectivity, leveraging the mass deployment and use of sensors to the mainstream. Such transient sensor grids are to be composed of virtual sensor nodes contributed by more than one physical sensornets while offering a common processing view and sharing semantics, in spite of the inherent heterogeneity in ownership, hardware and operating systems for the hosting nodes.

Categories and Subject Descriptors
C.3 [Special-purpose and Application-based System]: Real-time and embedded systems.

General Terms

Keywords
Wireless PAN, virtualization, Internet integration, peer-to-peer network.

1. INTRODUCTION
In not too distant future, sensor nodes are likely to be deployed in various capabilities by private citizens, social groups, non-profit and commercial organizations and governments alike. While private use such as asset/health monitoring and home security may remain to be the primary reasons behind these deployments, their ubiquitous span offers a great potential for community use.

We explore the possibilities of forming scalable community-based transient sensornets based on a non-exclusive total access model, so that ordinary citizens are empowered to program networked sensing applications expanding the reach beyond their ownership. Sensor nodes can adverstize their capabilities/service over a peer-to-peer (P2P) network formed by their respective Internet gateways; and a user with proper credentials can discover such nodes within the intended area of coverage, thereby forming a new virtual sensornet to inject a sensing task without disturbing the ongoing primary tasks at any node.

Thus a typical user belonging to the community often borrows sensor node capabilities from parts of the community sensornet infrastructure to form a transient virtual sensornet over a desired area of coverage. The rules of sharing are dictated by the owner of the resource and at no time the sensing task of a local or remote user should violate the authority, privacy and security of the provider.

2. APPLICATIONS
Consider a scenario in urban sensing, where a city is interested in vigilance on brush fire to actuate an early response system. Harnessing city owned sensors as well as enticing citizens to deploy mote-based sensornets within their property at their own cost can efficiently solve the sensing problem. Contour detection needs adaptive sampling of temperature based on frequent single hop exchange of readings among neighbors. Forming a community sensor grid would support seamless direct data exchange possibilities between sensor nodes owned by the city and the citizens, leading to an energy-efficient implementation of contour detection leveraging in-network aggregation and processing.

Scalable design of a large micro-monitoring infrastructure such as the one needed by NEON (National Ecological Observatory Network) to supplement its remote-sensing mechanisms would also be benefited by the community
sensor grid based design. Even for a single organization, it is more logical to divide large infrastructure into constituents under local maintenance and administration. While this instills artificial boundaries, a technique for authenticating a remote user to form a guest sensornet and inject a sensing application thread can easily overcome the limitation imposed by administrative boundaries.

Constituent sensornets (administrative domains)

Community sensor grid of virtual nodes

Figure 1: Forming a community sensor grid

3. ARCHITECTURE

A sensornet today has a commonly accepted structure of being a cloud of sensor nodes hanging off of a gateway at the edge of the Internet. The idea of grid integration of sensornets is relatively new and is indeed in a nascent stage.

In brief, the community sensor grid architecture consists of: (1) virtualized sensor nodes, where each virtual node is hosted on a physical node but may run a sensing task isolated from other instances of virtualized views of the same node, (2) network connectivity for each virtual node despite their existence on different physical wireless PANs that may operate on different channels, (3) a single sensornet view offered across diverse administrative domains as in Figure 1, (4) a transient underlay that allows sensing tasks running on a node cluster to bypass IP gateways if the participating virtual nodes can find a reliable path with less hops through a neighbor across hosing domains, (5) a P2P overlay network that ties together the IP gateways to the constituent underlays of the sensor grid, (6) and a robust security and access control management system that uses certificates, user accounts and role for authentication and access privilege granting [1].

4. DEPLOYMENT: SEARCH/FORMATION

The deployment of the sensor grids are expected to be viral along with incentives offered by governmental agencies and special interest groups. However, the viral growth would be limited or impossible without a search and configure infrastructure that can be human-driven, similar to the Web 2.0 systems.

We are investigating several mechanisms, centralized as well as decentralized, to allow expert users form customized community sensor grids by gluing together multiple sensornets (administrative domains), as well as casual users to use pre-configured grids for data access and in-situ aggregation. Prevalence of human factors in discovering sensor coverage and services calls for handling transience and flexible query semantics, making DHT-based structured P2P search strategies inappropriate for the search and configure operations [2].

The first-level sensornet advertising medium would be a site such as Geocaching (http://www.geocaching.com) which allows location-based lookups, a map-based mashup and the ability for anyone to post details about a sensor network. Such a scheme would be centralized and provide geographical attributes like Microsoft SensorMap [3]. The second-level method would be to advertise virtual sensor grids that are configured and available for use using a web page that is similar to group web sites, such as Meetup (http://www.meetup.com). This method can allow not only geographical but attribute based searches.

Fine grain attribute-based lookups can be done via several methods involving personal or community web pages using established terms and attributes that are searchable via search engines. Databases can be built from such information that provides more automated searching with attributes (e.g. http://www.realtor.com). Finally, some sites are expected to provide access to aggregated, real-time, sensor data. Such sites would in turn use a sensor-grid to obtain raw data, and provide a user interface (visual or data-streaming) for generating as well as visualizing useful aggregated data, such as those provided by live financial data sources.

5. ACKNOWLEDGMENTS

This material is based upon work supported by NSF under Grants no. CNS-0551734 and CNS-0617671, and a GREG award from the New Mexico State University.

6. REFERENCES

