Demo Abstract: The Signpost Network

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ABSTRACT

The era of city-scale sensing is dawning. Supported by new sensing capabilities, the capability to detect and measure phenomena throughout a large area will allow deeper insight and understanding into how cities work. The challenge of city-scale sensing is not limited to developing new sensing applications, however. A sensor must be installed in a location. It must be provided power, storage, and communications. All these tasks stand aside from the desired sensing effort, but are necessary nevertheless.

In this demo, we introduce an initial prototype for a modular, city-scale sensing platform—the signpost network. The platform, designed to be physically attached to sign posts throughout a city, reduces the burden for sensor and application developers by providing the necessary resources to modules attached to it. Power is provided by harvesting from solar panels with battery storage, with each module allocated a certain subset of the system energy. The signpost platform also provides data storage, long-range communication, data processing, module isolation, and an installation point for connected modules. The signpost acts as a modular base station for researchers, citizen scientists, and other interested parties to deploy custom sensors for applications such as pedestrian counting, air quality monitoring, and RF spectrum sensing at a city-wide scale.

Categories and Subject Descriptors

B.4.2 [**HARDWARE**]: Input/Output and Data Communications—*Input/Output Devices*; C.3 [**COMPUTER-COMMUNICATION NETWORKS**]: Special-Purpose and Application-Based Systems

Keywords

City-scale sensing, Modular architecture, Energy harvesting

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Figure 1: **Signpost in an urban setting.** Sign posts are natural and unobtrusive sights in even modestly urban settings. The form factor is conducive to reasonably large solar panels and provides area for mounting a diverse array of sensor modules, all while blending into the background environment of a city.

1. INTRODUCTION

It is well-known in the sensor networking community that in many cases, "sensing" is the easy part. The most challenging aspects of many deployments are providing energy to the sensor, facilitating a reliable communication channel, handling long-term storage of sensor data, and in many cases physically deploying the sensor itself.

In this demo, we begin to explore a possible new approach to solving these challenges in urban environments. In contrast to previous city-scale deployments, which rely on cooperation from local industries such as taxi and bus companies [1] or the local municipality [2], we aim to provide a standalone infrastructure by deploying a network of energy-harvesting signposts, such as that seen in Figure 1.

Our proposed signpost platform includes a large, sign-sized solar panel for energy harvesting, a battery for time-shifting energy availability, a power module for metering, rationing, and distributing energy, a communications module for cloud and signpost-to-signpost connectivity, a storage module for long-term data collection, a computation module for local processing, and a controller module to manage all of these components. The signpost uses these modules to provide the essential services – energy, storage, computation, and communication – to sensor modules that plug in to the signpost.

The goal of the signpost network is to act as an easily deployable, infrastructure-independent platform for city-scale sensing. Persons

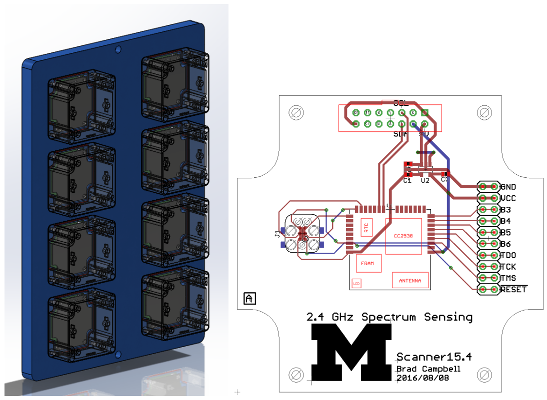

Figure 2: **Signpost platform and example module circuit board.** Signpost enables multiple modules to be installed and share resources such as power, storage, communications, and processing. By bearing the burden of providing essential resources, signpost enables sensing modules and applications to be simple to create.

interested in deploying wide-ranging urban sensor networks can focus on their sensing and processing applications while relying on the signpost to provide the basic infrastructure requirements. At the same time, our proposed signpost network requires minimal support from local municipalities, not tying into local electrical grids, affixing to buildings, or requiring any specialized placement other than the modest area of a sign post.

2. THE SIGNPOST

In order to reduce the burden of city-scale sensing deployments, the signpost platform provides several capabilities to its modules. These include installation, isolation, power, storage, communication, and computation. Within the signpost platform, a central controller is in charge of monitoring and commanding module activities.

Physically installing devices throughout a city is an often overlooked challenge. Locations for each installation must be selected, work orders must be placed, and cases must be created for each device to provide security and environmental protection. Signpost provides a standard interface for a module and its waterproof enclosure. By enabling modularity, signpost incurs many installation costs only for initial installation. Additional sensors can be added to an already existing deployment.

Each module must be isolated from the others in order to ensure that the system will not be negatively impacted by faulty or malicious modules. Signpost provides physical isolation through its case design, and electrical isolation of all buses connecting to a module. If, during operation, a fault is detected in a particular module, the controller can cut it off from the rest of the system and continue operation without it.

Power is a signification concern for all sensor network deployments. Batteries, while frequently used, inherently limit the lifetime of the deployment. Connection to AC mains power is ideal for high-power applications, but is expensive or infeasible to install in many locations. Instead, signpost is an energy-harvesting platform, taking advantage of outdoor solar power. The collected coulombs are then explicitly allocated to modules based on priority, with the controller monitoring each module's usage. Modules wanting to adapt to the current energy conditions can query the controller for their remaining allocation and modify their behavior. Modules wishing to be agnostic can do so, but will be shut down by the controller once their energy allotment is depleted.

City-scale sensing requires communication in two forms: data backhaul and signpost-to-signpost. Eventually, data from sensing modules must make it back to be evaluated and understood. Cellular or WiFi networks are commonly used for such tasks. Each, however, has drawbacks in terms of cost and availability. For some applications, such as pedestrian tracking, signposts must communicate with each other in order to corroborate and share measurements. While this communication could happen through the cloud, direct communication between signposts can reduce latency. Signpost provides both capabilities through LoRa, a low-power wide area network operating in the 915 MHz band.

Finally, data collection necessitates storage and processing capabilities. While each module can maintain its own storage, they may also take advantage of a centralized data store. This can be used by applications which synthesize data from several modules in order to gain deeper insight. Since processing collected data in embedded code can be a difficult task, signpost introduces the capability of Linux-as-a-coprocessor. Each module can request to activate the Linux, running applications of their choosing and paying out of their own allotted energy store.

3. DEMO

For the demo, we will bring a signpost platform with several installed sensing modules, demonstrating the signpost architecture as well as several possible applications. The platform will be capable of energy-harvesting, power allocation, module isolation, data storage, data processing, and long-range communication. Modules and applications include an RF-spectrum sensing module, shown in Figure 2, an environmental sensor, and a pedestrian tracker.

Along with demonstrating the applications themselves, we will show how the signpost architecture enables and affects the sensing modules. This includes automatically adapting module duty-cycle as stored energy fluctuates and enabling local synthesis and processing of data from multiple applications.

As we expect the demonstration space to be indoors, we plan to simulate the signpost adapting to dynamic energy availability (i.e. how much energy the solar panel is collecting), however, if a space near a window, sunlight, and/or the outdoors is available, that would be ideal.

4. ACKNOWLEDGMENTS

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