Demo Abstract: Zoom – A Multi-Resolution Tasking Framework for Crowdsourced Geo-Spatial Sensing

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Abstract

Current sensor networks have limited use after deployment due to the lack of ability to dynamically update sensing tasks to the networks. Assigning multiple tasks to multiple sensor groups in a sensor network deployed over a large geographical region at fine granularity becomes problematic because the sensors are heterogeneous, potentially mobile, and owned by users instead of network operators. We demonstrate Zoom [3], a multi-resolution tasking framework for crowdsourced geo-spatial sensor networks. The key idea in Zoom is decoupling the task specification from the task implementation using a spatial 2-dimensional representation of the tasking region (e.g., maps). Zoom allows users to define sensor groups over heterogeneous, unstructured and mobile networks and assign different sensing tasks to each group. To the best of our knowledge, this is the first work to propose a map based approach for mobile sensing systems.

1 Introduction

As sensor networking technologies continue to develop, the notion of creating *multi-purpose multi-user* sensing systems is becoming feasible[1, 2]. It is possible to share the same sensor network to support multiple applications for different users. For example, sensors deployed over large geographical urban regions [2] could be used by different users for different purposes such as noise monitoring and traffic monitoring.

To enable multi-purpose multi-user sensing systems, sensor networks must be able to update their sensing tasks dynamically. The sensor networks will often need to perform different tasks over different spatial-temporal regions depending on the dynamics of the phenomena being studied.

Despite its critical importance, tasking has not been widely addressed in prior research. Previous approaches to tasking sensor networks either do not scale well to large sensing regions [4], consuming significant network resources such as energy and bandwidth while incurring significant latency.

In this paper, we demonstrate Zoom [3], a multi-resolution tasking framework, applied to mobile sensor networks. This framework allows users to group and assign tasks to sensors in non-uniform, fine-grained ways across a large sensing region for heterogeneous mobile sensor networks. The key ideas in Zoom are (i) decoupling task specification and task implementation to support heterogeneity, (ii) using a spatial 2D representation such as maps for representing sensor groups and the tasks to scale with the number of nodes and sensing regions, and (iii) using image encoding techniques to reduce the map size and provide adaptation to sensor platforms with different resource capability. Zoom is more intuitive, efficient and scalable compared to previous approaches.

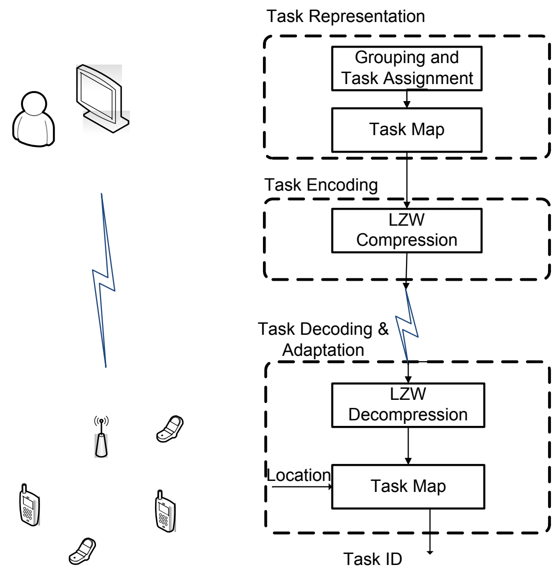

Figure 1. Zoom overview: Zoom has three main components: *task representation*, *task encoding*, and *resource adaptation*.

2 Zoom Tasking Framework

Zoom has three main components as illustrated in Figure 1: *task representation*, *task encoding*, and *resource adapta-*

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tion. Task representation focuses on designing the data structure that can specify sensor groups and assigning tasks to the groups. Task encoding focuses on how to compress the task data structure to reduce the data size. Finally, resource adaptation enables tasking for sensor devices with different resource capabilities.

Task representation and encoding is performed at the back end where an operator can define geographical regions and assign tasks to each region. The task IDs with the location information are represented as a task map; a location on the map corresponds to a real physical location and the pixel value at a particular location on the map is the corresponding task ID, which specifies the task to be performed at that location (Figure 2). The map is then encoded as an image in our defined *STIF format* and transmitted to the network.

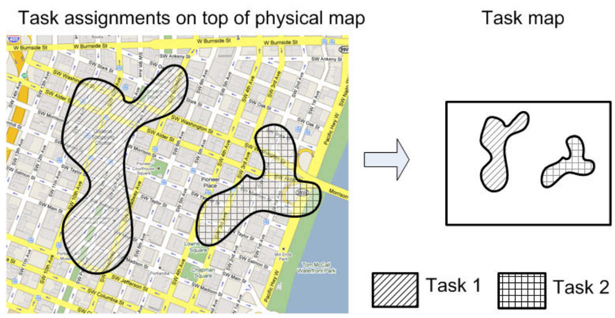

Figure 2. A task map overlaid on top of a physical topology: Physical groups of sensors can be viewed as a region in the image. Each pixel in the image represents a squared region in the physical map and the pixel value is the task ID. A node upon receiving a task map can calculate the value of the pixel in the map that corresponds to its physical location to know which task it should perform.

Upon receiving the encoded task map, a node removes the image header and decompresses the task map. The node calculates the pixel in the image that corresponds to its physical location and retrieves the ID of the task it needs to perform.

3 Demonstration Overview

We will show the Zoom complete tasking system (Figure 3) that allows the end user to dynamically create sensing tasks and adapt the mobile sensor network operations accordingly. A user participates in sensing by registering the user's smartphone with Zoom. The end user creates sensing tasks by specifying geographical regions (e.g., drawing on top of google map) and assigns a task ID to each region. The task map, which contains all regions and tasks, is encoded using the STIF format and disseminated to participating smartphones using the Android cloud to device messaging framework. A smartphone, upon receiving the task map, decodes the map and gets the ID of the task it should perform. The smartphone triggers the appropriate sensing program (e.g., a program to collect noise and GPS data) based on the task ID. The sensing data is reported to a basestation, stored in a database, and can be visualized back to the end user in real-time.

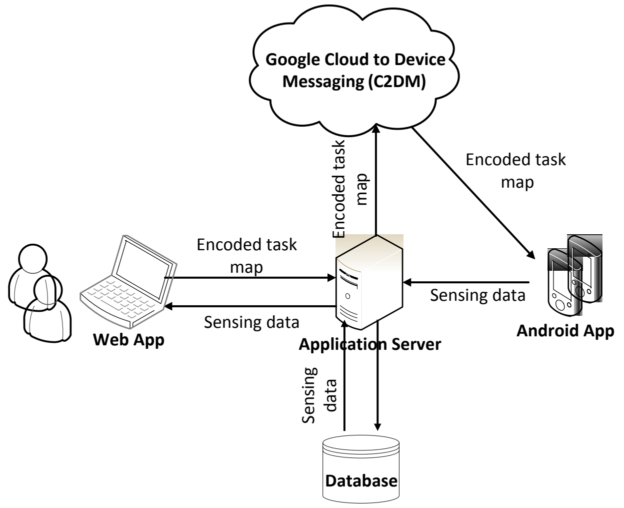

Figure 3. Zoom tasking system

We will demonstrate that Zoom is visually intuitive and scales well with the large sensing regions and the number of nodes. The use of maps also allows a node to quickly obtain its task ID without running complex geometric algorithms to determine whether it belongs to a region or not. We will also present three resource adaptation techniques in Zoom to reduce memory, bandwidth and CPU usage. To the best of our knowledge, this is the first work to propose a map based approach for mobile sensing systems. We believe that Zoom's tasking capability is a step toward providing structure in increasingly unstructured mobile geo-spatial sensing systems.

4 References

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