Android at Bandon Bay: Low-Cost Environmental Monitoring and Event Detection Using Smartphones

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***Abstract*— Our work builds on open source technologies and standards to provide a system for real-time event detection in Bandon Bay, Thailand. Our system leverages the availability and versatility of mobile devices for effective low-cost monitoring in a region that is devoid of power and is prone to frequent cellular disruptions.**

Keywords*— *Android; Real-time Analysis; Environmental; Observing System; Water Quality; Event Detection; Mobile Computing;

I. Motivation

Bandon Bay, Surathani province, is home to mussel, cockle, oyster, and shrimp farmers. In March 2011, severe rainfall in the southern region of Thailand caused an influx of freshwater and sediment into the bay. Cockle and oysters were suffocated by a thick layer of sediment. The surge of water forced shrimp out into the open ocean. [1] The impact on the region was massive, with over half a million people affected [2]. In particular, the aquaculture industry suffered immensely. The aim of this project is to provide a valuable service to the region by giving farmers and locals a resource for assessing the water quality in Bandon Bay, as well as providing a warning system against possibly treacherous environmental patterns.

This work is part of a larger collaborative project, which enables the use of mobile devices for communication and computation for environmental sensor networks in regions without significant infrastructure. The work is a partnership between the Center of Excellence for Eco-informatics at Walailak University, the University of California Santa Barbara, and the University of California San Diego. It brings computer scientists and biologists together for the development of technology aimed at studying Thailand's costal ecosystems.

II. Goals

1. To provide a valuable service to the region by giving farmers and locals a resource for assessing the water quality in the bay.
2. To provide the tools to develop an early warning system to farmers and locals.
3. To use open source software and cost effective hardware to create a sustainable system that is affordable for use in developing regions.

III. System Overview

A. Real-Time Data Collection

Before detection can take place, the site first requires a system for real-time data acquisition. This is not a trivial task because the environmental conditions in the bay require a low power device that is capable of robust wireless communication. While there are industry devices capable of this, such as the Campbell Scientific sensor suites, they are prohibitively expensive for developing nations and are heavily proprietary, impeding expansion and development. After testing several systems, including a low-cost netbook and a Raspberry Pi, we determined that a mobile device running open source software is a perfect candidate. An Android smartphone is inherently capable of cellular communication, has a backup battery for intermittent power loss, and has the computing power necessary for data ingestion and onboard processing from a multitude of meteorological and aquatic sensors.

Mobile devices lack a native interface for accessing ecological sensors, which typically communicate via RS-232 or SDI-12 using both digital and analog protocols for communication. As we did not want to implement a proprietary system, we decided to build upon the Open Source SensorPod software stack developed at UCSD [3] for interfacing with environmental sensors.

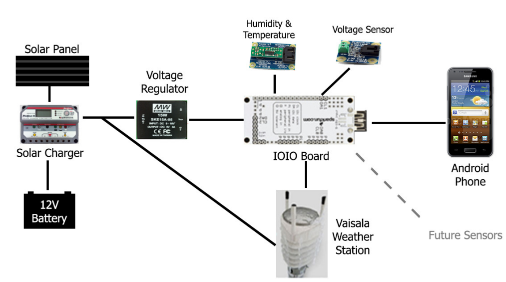

Fig. 1. Data Collection Platform

We recently deployed the system in the Gulf of Thailand, four kilometers off the coast. The system utilizes a Galaxy Nexus Android phone for real-time data collection and processing. For power, the system uses a 40W solar panel. The data is transmitted using the phone's built in cellular modem. The system utilizes a SparkFun Electronics IOIO for interfacing to external sensors and power. The phone currently interfaces with a Vaisala WXT 520 meteorological station, with plans to extend the sensor suite to include water sensors for conductivity, dissolved oxygen, and pH.

B. Real-Time Event-Detection

The phone streams the data to an Amazon EC2 server utilizing the Open Source Data Turbine streaming middleware [4] for real-time buffered data streaming and visualization. This middleware is used internationally by many communities of ecologists as well as other disciplines requiring real-time data streaming. By building upon an existing system for reliable real-time data delivery, we wanted to allow interoperability with other tools and technologies developed by the ecological community. Through this approach our system can be used as infrastructure for future applications.

For event detection, the system integrates with Esper [5], a free and publically available complex event processing engine. Sensor streams captured via Data Turbine are sent through "SQL like" queries running on ESPER. When an event is detected, it activates a trigger, which marks this as an event of interest. In a later iteration of the system, an email, text message, or any other form of notification will be sent when a hazardous event is detected. By once again utilizing a freely available off the shelf system, Thai researchers can utilize the full power and feature set of a developed product, contributing to the sustainability and flexibility of the system.

While this iteration of the system runs at the server, ideally this detection code would run on the mobile device. Unfortunately, despite being written in Java, ESPER is currently only partially supported for Android and still remains unsuitable for this application. We hope that there will be an official Android version of ESPER or a comparable event processing engine, as there is already considerable interest.

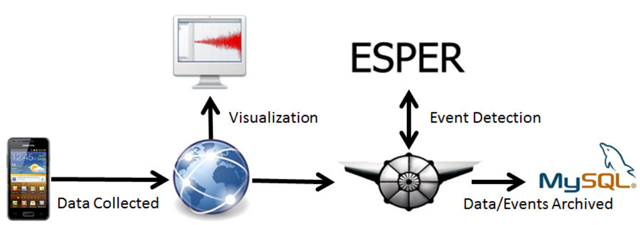

Fig. 2. Data Flow Schematic

IV. RESULTS

We built on existing technologies to develop a novel system for real-time environmental monitoring of Bandon Bay. A mobile device collects and streams the data to a cloud server. The data is then run through a real-time event detection engine. Both the original data and the derived analysis are then made publically accessible and mirrored to universities in Thailand in real-time, using the DataTurbine middleware. Interested parties can visualize both the data and the derived analysis in real-time. The system utilizes solar power, and is tolerant of network disruption.

This system leverages the availability and versatility of mobile devices for low-cost effective monitoring. Thailand is a developing nation and cost plays a major factor in the feasibility of a system. Our monitoring solution utilizes freely accessible software (open source whenever possible) and off the shelf hardware requiring only minor customization to create a system that is not only powerful but affordable to deploy and maintain. As our system continues to grow and develop, we hope that it enables sustained automated monitoring and a platform for disaster detection in a critical region of a developing nation.

V. FUTURE WORK

Our work has sparked interest from other groups who are using common technologies for data collection. At a workshop at the start of July 2013, we met with groups from Taiwan (Forestry, Agriculture, Endemic Study), as well as engineers from NECTEC Thailand, and the University of Wisconsin Madison. We are exploring possibilities of adopting our work to other sites for using mobile devices for the automated detection of environmental factors.

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