Instrumenting Thailand's Coastline: Cyber-Infrastructure for Environmental and Disaster Monitoring

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Introduction

Location

Bandon Bay, Sura Thani province is located in the Gulf of Thailand. This rural area is home to mussel, cockle, oyster, and shrimp farmers. The bay is shallow, less than 5 meters deep in most places, and is an ideal location for aquaculture, which takes place around freestanding structures in the water a mile or more from land. The farming structures lack power and internet.

Map of Deployment in Thailand

Motivation

With many estuaries feeding the bay and the frequency of storms, this area is susceptible to flooding. During periods of heavy rain, sudden influxes of freshwater and sediment pour into the bay. Cockle and oysters suffocate under the sediment, and the surge can force shrimp out into the open ocean. In March 2011, one such flood caused losses upwards of 800,000,000 THB (~$30,000,000 USD).

Goals

1. Provide a valuable service to the region by giving farmers and locals a resource for assessing water quality in the bay.

2. Understand the environmental patterns that lead to flooding and other treacherous events.

3. Provide an early warning system to farmers and locals.

4. Use open source software and cost effective hardware to insure the system is affordable for use in developing regions

Aquaculture Farm in Bandon Bay

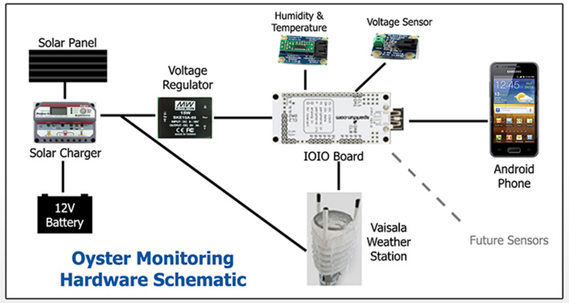
Materials & Method

Real-Time Monitoring

We are transmitting data in real-time from the bay. Currently, we use a Vaisala weather station, which measures meteorological data (rainfall, wind, humidity, barometer, & temperature).

The final System will utilize:
- Weather Station (rain, wind, humidity, barometer, temp.)
- Thermistors (water temperature)
- DO Sensor (dissolved oxygen)
- pH Sensor (acidity)
- Conductivity (salinity)

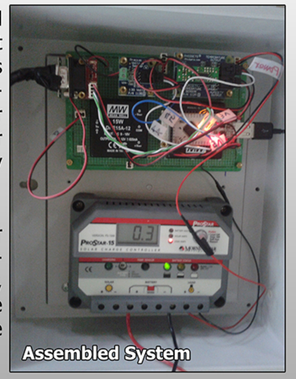
In order to log the data, we capture the output of the instruments via a mobile phone running Android with the help of a SparkFun Electronics IOIO board and a "Sensor Pod" software stack developed by the CLEOS lab at UCSD. Reliability of data delivery is accomplished via DataTurbine and open source data streaming middleware



Oyster Monitoring Hardware Schematic

After testing a netbook and Raspberry Pi, we decided that an Android mobile device is the ideal choice for data collection, as it has low power consumption, built in cellular modem, and is natively capable of running Java.

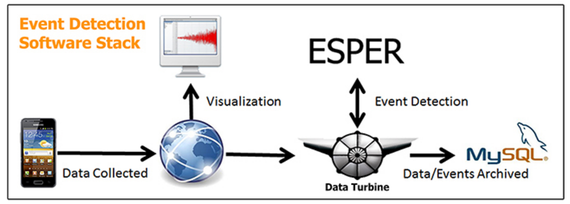
We utilize solar cells for power and built in 3G for data transmission. On-board humidity, temperature, and voltage sensors allow us to analyze the state of the equipment.



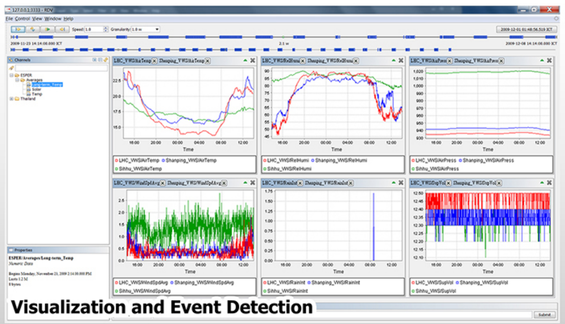
Assembled System

Event Detection

Event detection is done at a Walailak University server using ESPER, 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.



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.



Visualization and Event Detection

Identifying Flooding Factors

The Thailand meteorological agency has a weather station on the shore of the bay that records meteorological data. While these records are not accessible in real-time, they serve as a good baseline for identifying the factors that lead to flooding. We have access to data from their site going back 30 years to 1983. We are cross-referencing this data with known storms and flooding events to identify contributing factors.

Results

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.

Future Work

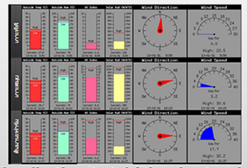
Continuing Development

The system is a prototype and is continuing to develop. Reliability of the system is still far from optimal, as bad weather interferes with the cellular reception out in the bay. We are investigating ways of amplifying the signal. Further, while the system for event detection is in place, we are currently using only a naive set of parameters and will need to refine them for the final system.

Visualization

Currently, we use RDV (Real-Time Data Viewer) for visualizing streaming data. While this solution works well for scientists, it is not suitable for the public as it uses a standalone Java Client.

In future phases of the project, we plan to adapt a visualization system developed by Walailak University for the creation of a web portal.



Visualization Portal (Planning to Adapt)

Uses in Other Fields

We are developing this system in conjunction with the Taiwan Forestry Research Institute, who are using remote sensing to study the ecology of forests in Taiwan, and the University of California San Diego, who are using it for lake ecology. The ability to combine affordable remote sensing with event detection has also sparked the interest of researchers in the fields of coral reef and lagoon monitoring.