SEAMONSTER: A Sensor Web Technology Implementation and Testbed in Southeast Alaska

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***Abstract*-SEAMONSTER, the South East Alaska MOnitoring Network for Science Telecommunications Education and Research, is a smart sensor web project designed to support collaborative environmental science with near real time recovery of large volumes of environmental data. The Year One geographic focus is the Lemon Creek watershed near Juneau, Alaska with expansion planned for subsequent years up into the Juneau Icefield and into the coastal marine environment of the Alexander Archipelago and the Tongass National Forest. We will discuss overall sensor web design, sensor, mote, communication, data aggregation and "in-web" analysis, and data distribution to end users as implemented in SEAMONSTER.**

I. Introduction

SEAMONSTER, the SouthEast Alaska MOnitoring Network for Science Technology Education and Research, is an effort to instantiate a sensor web in Southeast Alaska. The premise of the project is that the technological developments of many aspects of sensor webs are mature enough to be implemented as an educational tool, a scientific resource, and a sensor web testbed.

A sensor web is a network of sensors that has the additional ability to adapt individual sensor or entire sensor web performance and allocation of resources based on the near real time sensed environment [1]. The technologies required for sensor webs include sensors, power management, communication, data aggregation and *in-situ* analysis, data storage (both in-web and externally), and data access and visualization.

This paper highlights the design and status of SEAMONSTER. Lessons learned, technology infusion, and testbed integration with other projects will be described in the talk.

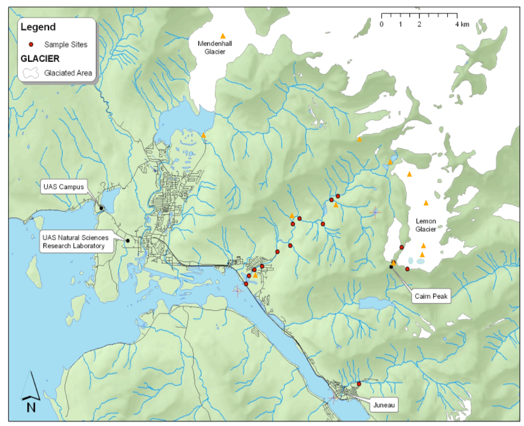

Fig. 1. Lemon Creek Watershed and surrounding area.

II. Sensor Web Application

The Lemon Creek watershed illustrated in Fig. 1 is accessible from Juneau while covering the sea to icefield range of environments found in Southeast Alaska. Micro-sensor clusters of motes are indicated as red dots and micro-server nodes are orange triangles in this example installation. The Lemon Creek watershed is relatively compact (~100 km^2) and begins on Lemon Glacier with two supra-glacial lakes at its head. These lakes have periodic outburst drainages that enter Lemon Creek proper via sub-glacial drainage channels. Below the glacier, Lemon Creek flows through steep wilderness terrain, fed by several tributaries, before reaching a region of active mining and industrially zoned use, and finally flowing past residential housing in Juneau and emptying into the ocean.

The general scenario of a sensor web application requiring long-term monitoring to successfully observe an impulsive event of interest is well served in the Lemon Creek example. The outburst flood represents a single event which influences several aspects of the watershed—cryosphere (*e.g.* glacial motion), hydrosphere (*e.g.* water temperature, turbidity), and biosphere (*e.g.* spawning salmon).

III. Sensor Web Implementation

Modularity of design is a major component of the SEAMONSTER design philosophy. This is required in order to easily integrate new sensors and technology improvements, and build redundant, fault-tolerant systems. Even in the modest first year of deployment, SEAMONSTER sensors include temperature, wind speed, wind direction, atmospheric pressure, water pressure (water level), water turbidity, water chemistry (*e.g.* dissolved oxygen), snow depth, glacial movement (differential GPS), glacial activity (geophones), and video. Managing these data streams and providing ease of adding additional, un-anticipated sensors requires modularity in data handling. The various platforms of the sensor web also require modularity. Tier-1 sensor web hardware (Fig. 2) consists of PC-104 based microservers with microcontroller power control, communications range of order 10 km, local storage, command and control, and power consumption between 0.5-10 Watts depending on configuration. Tier-2 sensor web hardware is a small low-cost, low-power processor bonded to a radio. These nodes in SEAMONSTER are made of tMote sky nodes from Moteiv. Other commercial “mote” nodes are also being explored to understand the realities of operating a heterogeneous sensor web.

A. Communications

The most important distinction between a sensor network and a sensor web is the communication between sensor nodes and the associated adaptation in behavior. The communication of SEAMONSTER is designed to maximize bandwidth and minimize power consumption while monitoring cost. Additionally, redundancy and reliability are important design considerations. The sensor node spacing allows for the use of 802.11g as our primary communication protocol. We make use of directional antennae. For backup communication, we also use 900 MHz radio modems and Iridium modem uplinks. The sensor web will adapt communication behavior based on the bandwidth available.

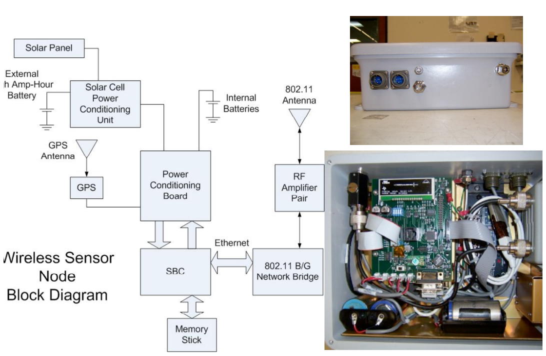

Fig. 2. Microserver Node schematic and photo.

B. Documentation

A major component of SEAMONSTER is documenting the entire development of the sensor web, at every step. We are including the documentation and planning in an open and available forum, enabling early collaboration with other groups, by adopting a wiki infrastructure. This is available at http://robfatland.net/seamonster/

C. Environment

As mentioned in Section II, SEAMONSTER covers sea to icefield environments with relatively easy physical access. Fig. 3 illustrates the two supraglacial lakes (from the web camera vantage point) the top of the watershed/study-site. Fig. 3 also illustrates two students involved in water quality sampling crossing the watershed about halfway to the ocean from the lakes.

Fig.3. Two views of the Lemon Creek Watershed.

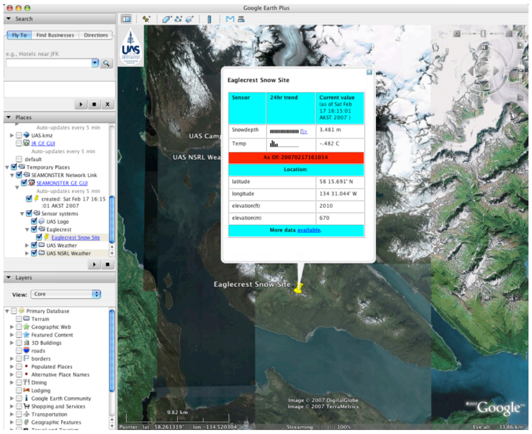

Fig. 4. Data dissemination via kml as viewed in Google Earth.

D. Data Management and Dissemination

The multiple diverse streams of data contributing to SEAMONSTER are eventually exfiltrated from the sensor web and stored in a SQL database. From this database and sensorML definitions of the sensor web, a kml file is automatically updated. This file can be viewed in SEAMONSTER, WorldWind, and ESRI's suite of Arc* GIS products. This automatic generation of kml is currently working on a small number of sensors and the process is presently under development. The kml file is used to manage SEAMONSTER (to identify communication or node failures, for example), to provide access to the data by "owners" of specific instruments, and provide data access and public outreach to the general public.

A successful example of this public outreach was the placement of one weather station at the Eaglecrest Ski Area. In addition to the large amount of public interest in the snow depth measurements, the ski patrol used the snow depth, temperature, and wind observations to aid in avalanche control efforts.

The kml provides easy access for inclusion of SEAMONSTER in the undergraduate curriculum and partnerships with K-12 classrooms interested in monitoring the glaciers and watersheds of Southeast Alaska.

IV. Testbed Opportunities

Through the modularity of design of SEAMONSTER, we eagerly anticipate collaborations with other sensor web developers. We welcome the use of the SEAMONSTER sensor web to test software, host sensor platforms or sensors for testing in harsh environments before deployments with less accessibility, incorporate SEAMONSTER into other sensor webs, and seek to incorporate data management and dissemination advances.

V. Conclusions

SEAMONSTER is an effort to implement a sensor web available for science, education, and sensor web technology evaluation and advancement. The modularity of design allows easy upgrade and integration of other researchers. The presentation accompanying this brief overview of SEAMONSTER will describe the lessons learned and project status as we observe and implement the SEAMONSTER sensor web for the first "turn on" of the Lemon Creek Watershed.

Acknowledgments

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References

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