Demo: Snowcat5 - Networking in Snow

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ABSTRACT

The experiment described in this paper is focused on sensing snow conditions. The primary experiment site will be an igloo in the Swiss alps, but the same technology will also be used in more regular settings. The goals of the experiment are three-fold: first, to develop practical and inexpensive sensor hardware for these environments; second, to develop user interface concepts that are suitable for the indigenous people, home owners, and skiers alike; and finally, the experiment will use a Delay-Tolerant Networking router to link the sensors with the Internet.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous

General Terms

Experimenation, Measurement

Keywords

sensor networking, snow, igloos, DTN

1. INTRODUCTION

This paper describes an experiment focused on sensing snow conditions, such as snow accumulation and temperature in various parts of the snow volume.

The initial experiment focuses on two deployment cases. In the main experiment we will build into an igloo in the Swiss alps. But the same technology can also be used in more regular settings, such as measuring snow depth on roofs and gardens, or monitoring the development of a mountain snow pack over the course of the winter for avalanche prediction purposes.

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The goals of the experiment are three-fold: first, to develop practical and inexpensive sensor hardware for these environments. The challenges relating to this goal are discussed in Section 2. The second goal is to develop user interface concepts that are a natural fit with how people want to interact with technology embedded in their environment. These concepts are discussed in Section 3.

The third and final goal is to demonstrate the use of Delay-Tolerant Networking (DTN) [1, 7] in moving sensor data from the site of the experiment to the Internet. The detailed experimental set up is discussed in Section 4. Finally, some wild ideas beyond the basic experiment are discussed in Section 5.

2. PRACTICAL SNOW SENSING

Sensing in the snow presents a number of difficulties. It is essential that the technology is easy to install, inexpensive enough to be lost, and resistant to the harsh conditions. Our plan is to use temperature and solar radiation sensors based on the 1-Wire bus architecture [5]. This wired networking technology relies on commonly available cabling and supports inexpensive sensors that are very small, just a few millimeters across. The sensors can be powered remotely from the cable head-end.

The authors have previously used the 1-Wire sensors for monitoring building, ventilation, and weather conditions. These applications all required a different way to package and wire the sensors. The same applies for the snow application. Our initial design involves two different physical representations.

The first design targets the measurement of temperatures in the various locations buried in an igloo's wall. As igloos are typically constructed in a spiral fashion from cut or compressed blocks of snow, it will be easy to lay a spiral sensor cable along the igloo walls as they are being constructed. This sensor cable should be constructed in a "herringbone" configuration. A straight cable can measure temperatures within the igloo structure rising from base to apex, but short wire branches to additional sensors at intervals along the cable allow us to take measurements also closer to the outer or inner surfaces. Protective coating will be applied to the sensors and the cable connecting them to protect the system from being short-circuited by water.

The second design targets roof snow depth measurements and avalanche danger monitors. Here the sensors are placed in a transparent tube 25 - 50 millimetres in diameter and cut to a suitable length for the environment in question. Temperature and solar radiation (light) sensors are placed inside the tube in regular intervals. The "snowtube" is pushed into ground with the help of a metal spike or attached firmly to the roof. Techniques to provide a low thermal impedance path from the snow to the temperature sensors will include individual metal heat conductors in contact with the snow.

The readings from light sensors can be used to determine snow depth, and a history of temperature measurements can help provide an understanding of the conditions within the snow pack for the purposes of avalanche prediction.

The snowtubes can internally employ a 1-Wire chain of devices, and can be attached elsewhere via the same wire or alternatively, using a short range radio transmitter powered by batteries. In either case, the tube needs to be sealed to prevent moisture from affecting the electronics.

3. USER INTERFACES

The authors have experimented earlier with various types of user interfaces suitable for the "Internet of Things" devices communicating with humans. Our colleagues have developed a new concept, the Social Web Of Things (SWOT) that appears to be quite a natural way for humans to perceive this communication [4]. Our plan is to enable a Facebook friend interface for both snowpack and igloo measurements. The idea is that the system can generate events ("the snowpack on the roof is pretty thick") or the user can check detailed measurements by asking an associated bot about the status ("is my igloo melting?").

4. EXPERIMENTAL SETUP

Our network architecture is based on local wired networks and the use of a DTN between the sensors and the Internet. In this case we will make use of a DTN router previously developed for use in Northern Swedish summer conditions. [3, 6] The (solar-powered) DTN router will also supply power for the sensors.

For this experimental site we expect to be able to use a cellular uplink from the DTN router, which will store and encapsulate the sensor data before sending that to a DTN Internet gateway (for our experiment this is located in Dublin) from where the sensor data can be forwarded to anywhere on the Internet. Since the DTN router also acts as a Wi-Fi hotspot and runs a web server, people in the vicinity of the DTN router can also immediately access a web-based version of the user-interface.

The 1-Wire local wired network can be run as a chain of sensors at the physical layer while keeping the individual sensors individually addressable through their 64-bit identifiers. The chain terminates at a USB-based interface on the router giving access to the sensors while at the same time feeding power to the sensors via the cabling.

Power consumption of the sensor parts can be made extremely small in these applications, as it is necessary to power them up only very infrequently, such as once in a hour. Power consumption of the router and the uplink can be tailored to be substantially smaller than in traditional end-to-end designs, as we base our communications architecture on information-centric messaging where the site may "publish" information relatively infrequently. These publications are transported on DTN and then IP-based connections to application-layer proxies in the Internet, from where other devices can request information at any time. For this experiment, we may make use of an information-centric extension to the Bundle Protocol [2] that was previously developed.

In this case the DTN router will harvest energy via solar panels to supply the needs of the system. The router can be set to wake up according to a schedule that is configured to suit local conditions. Note that the use of this DTN router would probably be overkill for an operational snow monitoring network, however, the device is available, has the power management and DTN technologies required and is thus suitable for this initial experiment. A cheaper and less-capable unit would be appropriate for a real operational network.

5. WILD IDEAS

Some potential more advanced experiments include visualization of igloo conditions through projecting temperatures on the insides of the igloo itself, igloo shape analysis through embedded GPS positioning devices, having the snowtube sensors broadcast information to nearby skiers about the snowpack state, large-scale snowpack measurement network deployment as a multi-hop routed network, and full snowpack sensing techniques through ultrasound and other possible physical means. For gardening purposes, the authors are also interested in under-the-snow sensors with very infrequent communications about the temperatures experienced by the underlying vegetation.

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