Demo: Demonstration of a Snowpack Monitoring System based on Inexpensive Sensor Nodes and Solar-Powered Backhaul Links

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ABSTRACT

Evaluating the current risk of avalanches requires detailed data on snowpack characteristics. Some of these characteristics can be acquired by automatic measurement systems. We demonstrate a snowpack monitoring system based on inexpensive sensor nodes, that allow for high density monitoring. At regular intervals, an intermittent backhaul link forwards the collected data to the Internet. However, if the system detects a high risk level, it goes into emergency mode and immediately transmits a warning.

1. INTRODUCTION

In alpine environments avalanches claim lives and cause damages to settlements and infrastructure. Avalanche danger ratings were introduced to quantify the risk of such occurrences, and to initiate measures like avalanche blasting or closing roads and slopes. Moreover, mountaineers and tourists consult danger ratings to prevent risky situations. For reliable ratings it is indispensable to have detailed information on weather conditions and snowpack characteristics. This data is acquired by manual inspection and by automatic measurements. Manual snowpack profiling undoubtedly gives richer and more reliable information, but it is also a toilsome and lengthy process and requires experts. Automatic measurements can provide data from many more locations and at a higher sampling rate than manual profiling. It is common to use both methods in combination.

In our demonstration we present a snowpack monitoring system that is based on our inexpensive sensor node design INGA [1] equipped with a temperature sensor rod and our solar-powered DTN-Nodes [2] for backhaul. In contrast to other approaches [3, 4, 5] we implement a low cost solution. Therefore, it is possible to deploy a large amount of sensor nodes, allowing for measurements with a high spatial resolution.

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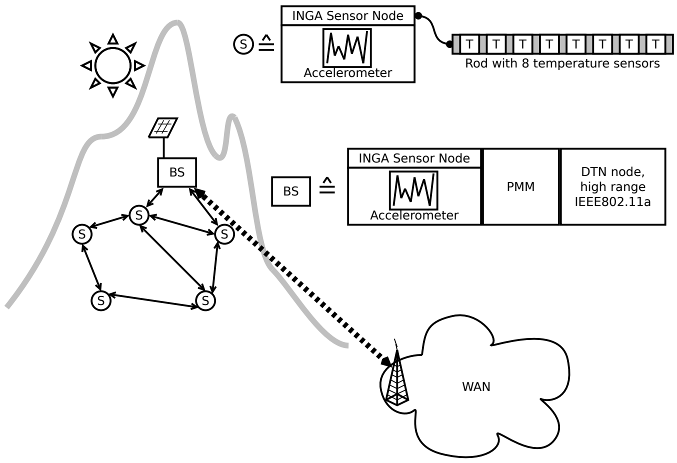

Figure 1: System architecture

2. ARCHITECTURE

Figure 1 shows the system design, which comprises several sensor nodes that are placed into the snowpack. The nodes are enclosed into plastic piping that also integrates several temperature sensors spaced 6.5cm apart, which measure the temperature in the various layers of the snowpack (a common procedure in snow profile analysis and also provides valuable data for avalanche research [6]). The data is collected at the nodes. It is forwarded using a simple routing protocol with IEEE 802.15.4. In regular intervals, the solar-powered node with the backhaul link is activated and forwards the data over a long distance radio link with directional antennas connected to the Internet using our DTN bundle protocol implementation. The output power of the IEEE 802.11a radio (Ubiquitiy XtremeRange5) is 28dBm. Moreover, each node integrates an accelerometer. If several nodes synchronously detect movement or vibrations, this indicates instability or even fracture initiation/propagation within the snow. In this case an avalanche is very likely. Therefore, the system switches to emergency operation and immediately activates the backhaul link to transmit a high priority warning.

In figure 2 a close-up of the components is shown. A snowpack monitoring node comprises an INGA WSN node with accelerometers and IEEE 802.15.4 radio, a temperature probe rod with eight DS18B20 temperature sensors, the en-

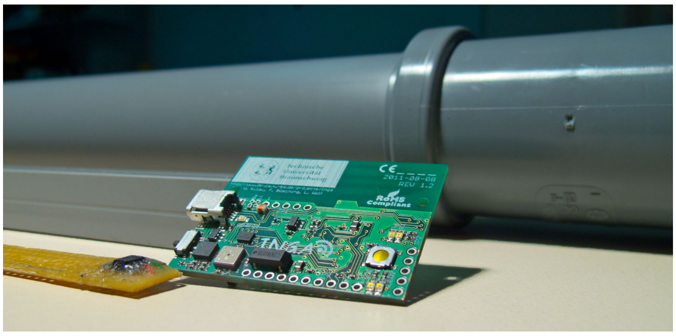

Figure 2: Components close-up of a snowpack monitoring node: INGA WSN node (middle), temperature probe rod (foreground), enclosure(background)

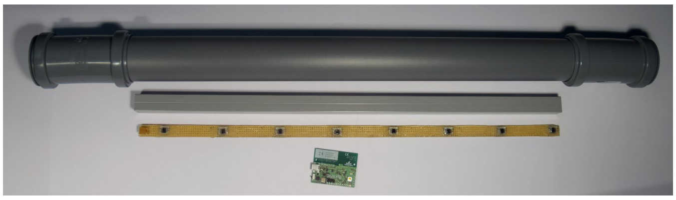

Figure 3: Components

closure, and batteries (not shown in the photo). The amount of temperature sensors, and the length of the temperature probe rod and enclosure are configurable to fit different applications (e.g. snowpacks with a thickness of several meters). Figure 3 shows the complete temperature probe rod and enclosure.

3. PRELIMINARY EVALUATION AND FIELD EXPERIMENTS

Currently, the system is already operational but still work in progress. Figure 4 shows a preliminary evaluation of the temperature probe rod, measuring a mock-up snowpack under lab conditions. In Figure 5 the 802.15.4 INGA radio range was evaluated in a sample measurement for recording RSSI values as a function of the distance. It exceeded our evaluation area and is above 300m in LoS, more than sufficient for the planned deployment in 50m intervals. The radio in the base station is a XBee-Pro RF module with a 10dBi omnidirectional antenna, the receiver sensitivity is -100dBm. The radio range for communication between two INGA nodes is about 250m.

Besides demonstrating our system at ExtremeCom, we would also like to conduct a field experiment, in which we evaluate radio range in a real-world extreme environment. Moreover, we would like to collect accelerometer data while people walk on the snowpack, in order to analyze if this could trigger a false snow fracture detection.

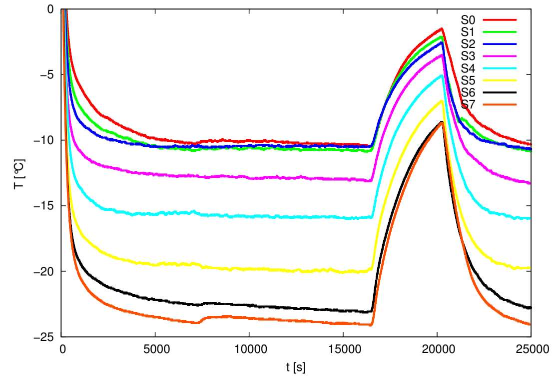

Figure 4: Temperature probe rod evaluation results

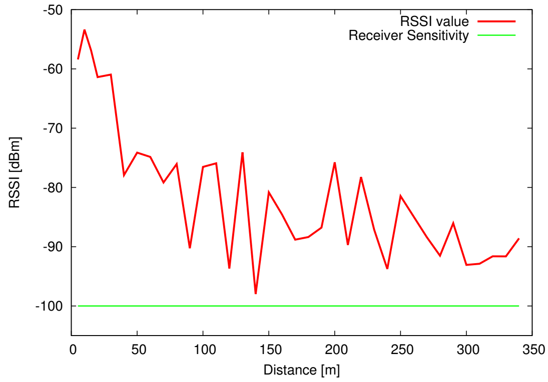

Figure 5: RSSI vs. Distance

4. REFERENCES

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