Hierarchical Sensing in Alpine Environmental Monitoring

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1 Motivation

The X-Sense [1] project is a joint effort by geosciences and engineering, which deploys networked embedded devices for measuring alpine environmental parameters in the swiss mountains. The processes controlling high alpine slope stability remain poorly understood. However, recent research [2, 3] suggests that changes in ground temperatures affect the thawing of permafrost, and thus adversely affect slope stability in high mountain areas.

Fiddes *et al.* [4] have investigated ground temperatures in high mountain areas using a collection of miniature temperature loggers to achieve high spatial and temporal resolution. However, the data recovery of these miniature embedded devices was cumbersome and time-consuming, thus warranting a more responsive and wireless sensing solution. Buchli *et al.* [5] have successfully applied wireless sensor network technologies to monitor alpine rock glacial movements using GPS-equipped sensor nodes. A network of GPS-equipped wireless data acquisition nodes synchronously collect GPS satellite data for high-accuracy and real-time positioning of alpine rock slopes.

This Master thesis aims to extend the existing GPS-equipped wireless sensor network to support hierarchical sensing, as illustrated in Figure 1. Each GPS-equipped wireless sensor not only performs synchronous GPS measurements, but also collects ground temperature data from a set of miniature wireless temperature sensors deployed in the vicinity of the GPS-equipped node. Point-to-point communication between the temperature sensors and the GPS-equipped node is achieved through a short-range ultra-low-power radio interface. A system abstraction of the wireless sensor platform into separate *sensing* and *communication* processors, as exemplified in [6], provides the necessary support for multi-sensor and hierarchical sensing paradigms. Furthermore, leveraging on the availability of GPS timing knowledge, an efficient time-synchronous wireless data transfer protocol between the miniature wireless temperature sensors and the GPS-equipped wireless sensor may be achieved.

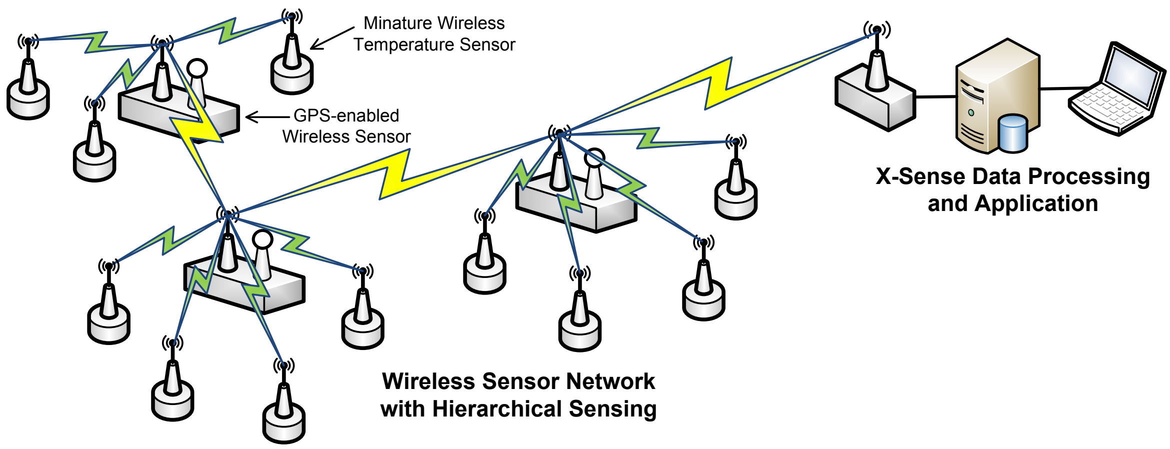

Fig. 1: Hierarchical sensing system concept.

2 Thesis Proposal

The goal of the Master Thesis is to design and implement a prototype end-to-end system capable of achieving hierarchical sensing using miniature wireless temperature sensors. The system architecture and the expected project work flow is illustrated in Figure 2.

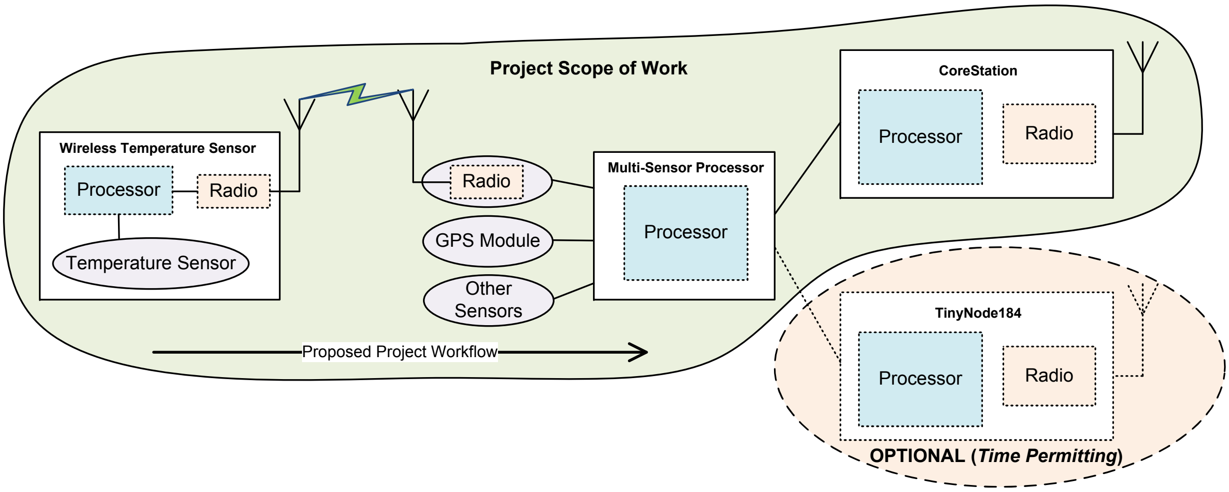

Fig. 2: System architecture and project scope of work.

The focus of this Master thesis is to achieve an end-to-end integration of multiple wireless temperature sensors together with a GPS module and/or other sensors which collectively form a hierarchical sensing network. The multi-sensor processor responsible for reading all sensors will be based on a commercially available ARM development board, which will be interfaced to an X-Sense CoreStation for connectivity to WLAN and/or Dozer networks. The integration towards a TinyNode184 platform is optional, based on time availability.

The anticipated work flow of the project begins with a design space exploration of the miniature wireless temperature sensor. The selection of a suitable temperature sensor, micro-controller, radio interface and suitable mechanics need careful consideration before the implementation of the software. It is envisaged that a printed circuit board and a suitable enclosure is manufactured for the wireless temperature sensors. The design and implementation of the communication protocol between the wireless temperature sensors and the multi-sensor processor will then follow, leveraging on the availability of GPS timing information. Finally, the multi-sensor processor must be interfaced to the short-range ultra-low-power radio module (which is viewed as an abstraction of a real sensor), the GPS module and CoreStation. Network connectivity over WLAN and/or Dozer is achieved through the existing CoreStation platform.

References

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