Investigating Permafrost with a WSN in the Swiss Alps

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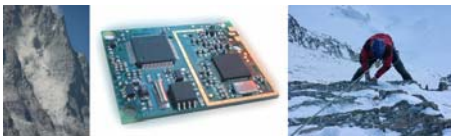
Introduction

In order to validate permafrost rock stability models, geo scientists need denser and more accurate data. So far, only simple data loggers existed that have to be read out via serial line. PermaSense provides a self-configuring wireless sensor field.



Project Mission

- Build a WSN for unmanned near-real time data monitoring in extreme environmental conditions.
- Produce data for permafrost research.

PermaSense at a Glance

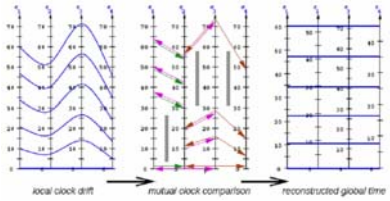
Adapting sensor data collection to an Intermittently Connected Network (ICN):

- long sleep cycles: power-aware hardware and protocol design.
- extended net partitions (e.g. due to ice).
- yet reliable data delivery.

"Skew Balance" Sync-Protocol

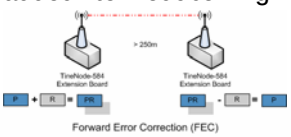
The protocol solves three time-related issues of ICNs:

- Local clock drift has to be compensated in order to let the sensor nodes wake up at preprogrammed times.
- Measurements have to be time-stamped with global time.
- Wakeup synchronization and accurate time stamping must be pursued despite extended periods without connectivity.



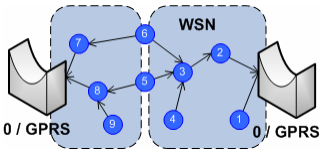
Reliable Node-to-Node Link

DECTED scheme (double error correction, triple error detection) scheme was added to reduce high packet losses.



Multi-hop Routing

Each gateway floods the net with reachability info, reverse paths form the spanning tree. Forwarding is integrated in the TDMA MAC scheme.

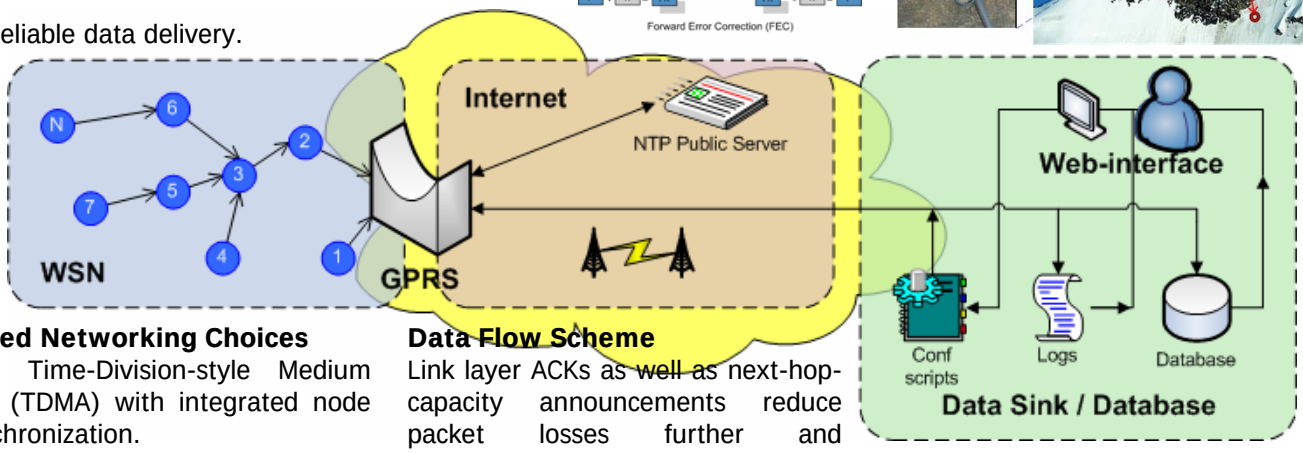


Multiple sinks (redundant GPRS gateways) are supported.

Results

Recently (Sep-Oct), the first PermaSense deployment took place in the Jungfraujoch region (3'500m above sea level):

- 10 sensors and 1 GPRS base station.
- Planned for at least 1 year unmanned operations.

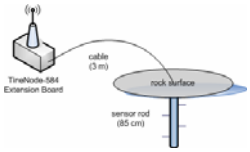


Selected Networking Choices

- Own Time-Division-style Medium Access (TDMA) with integrated node re-synchronization.
- Multi-hop: simple spanning tree.
- Robust data collection, in-network data replication.

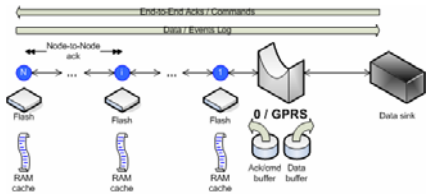
Custom Sensor Electronics (Rod)

- Temperature, rock moisture content and gradients in the near surface layer.
- Rod is detached from node, has unique ID.



Data Flow Scheme

Link layer ACKs as well as next-hop-capacity announcements reduce packet losses further and complement the end-to-end ACKs.



Various Runtime Parameters

- Duty cycle duration.
- Data sampling frequency.
- Data flow control flags.

A simple database using the UNIX file system to store data measurements and event logs; simple CGI-script based web-interface for browsing and chart generation; scalable duty cycle allows to observe the WSN in near-real time.

Further Work

A second WSN generation is planned for summer 2007. On the agenda:

- New sensor types: crack dilatation, seismic-acoustic events.
- Software chain improvements.

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