Poster Abstract: Using a heterogeneous sensor network to monitor glacial movement

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***Abstract*— It has been shown that by implementing a heterogeneous sensor network a glacier can be instrumented to allow for more detailed measurements and therefore facilitate more accurate modeling than has been previously possible. The heterogeneity comes from the use of multiple node types equipped with different CPUs and sensors, and different communication media.**

I. INTRODUCTION

The current theory amongst Glaciologists for how a glacier moves is known as 'stick-slip' motion [1]. This means that instead of moving continuously throughout the year the movement of a glacier occurs through a series of slip events. These events has been detected during short term field studies, however, there has been no previous glacial sensor network which can detect them. In this work it is shown that by using a heterogeneous network of different sensors a glacier can be monitored throughout the year to detect these events. The requirement to monitor different aspects of the environment led to a range of different node types. This led to the design and implementation of a common network layer and core ARM software deployed across the different node types.

II. NODE TYPES

There are multiple types of node deployed into the glacier, the majority of these form part of a single sensor network. The two exceptions to this are a camera node which is being trialed for future deployments, and 5 standalone differential GPS units. The idea would be to integrate them into the sensor network however, at this time it is not feasible.

Table I
Sensors deployed on subglacial probes

Sensor	Probe	Geophone
Temperature	Yes	Yes
Pressure	Yes	No
Strain	Yes	No
Accelerometer	Yes	Future Versions
Compass	Yes	Future Versions
Gyroscope	Yes	Future Versions
Conductivity	Yes	No
3D accelerometers	No	Yes

Manuscript received December 11, 2012. This work is currently funded by the Leverhulme Trust and National Geographic

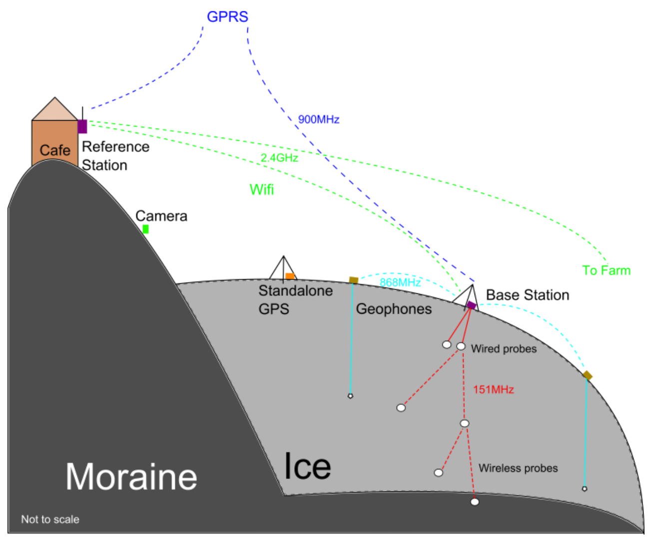

Fig. 1 Schematic of the entire deployment

However, whilst the data from these nodes is not available without manual retrieval and they are not linked directly into the sensor network their data is analyzed in conjunction with the data from the sensor network.

There are two different types of node deployed into the glacier, both are based on the Energy-Micro EFM32G230F128 ARM Cortex-M3 based MCU and use a microSD card for storage. The main differences between the two types of probe are the sensors attached and the way they sample and communicate. The differences between the attached sensors are summarized in Table I.

The probes are embedded in both the ice and the till layer (sediment beneath the ice), these sample their sensors according to a (user-definable) schedule and send the data back via a gateway probe using 100mW Radiometrix RPM1 transceivers at 151MHz. This frequency was chosen when transmitting through ice as the lower the frequency the better the propagation, leading to longer range. However, this does have the disadvantage of limiting bandwidth.

The geophones are attached directly to a surface node using a RS485 link, these surface nodes are used purely for relaying data. The reason for these surfaces nodes is that geophone nodes are expected to produce large volumes of data, so the serial link is more energy efficient. Once the data has reached the surface node it is then transferred using the 868MHz (CC1120 transceiver) network back to the base station. The base station then provides the link out from the glacier either using WiFi or GPRS depending on power and signal availability [2]. The other advantage of having the node on the surface is it enables power to be injected down to the geophone node, to provide more reserves if needed.

The geophones detect the shifts in the ice, in order to do this they have to be continuously sampling. However, continuous sampling from 3 sensors per node would lead to an explosion of data with no manageable way of storing it or transmitting it from the glacier. In order to avoid this whilst the nodes still sample continuously this is done in a low power mode, with the data being written to RAM using DMA. The input is also analyzed (in the analog domain) and if an impulse of magnitude greater than a preset level then the data is written to the SD card [3]. This is similar to the algorithm used in [4] An example showing the difference between a detected event and the background noise levels is shown in Fig. 2.

The probes however, do not perform event based detection, instead samples are taken according to a pre-configured schedule. This schedule can be reconfigured remotely (or from the base station) in order to enable the sampling interval to change based on forecasted conditions.

The base station which forms the central part of the network is the latest revision of the Gumsense [5] platform, it still uses the same philosophy of having both a high and low performance CPU, but now uses a Beagle Bone instead of a Gumstix, and a higher specification MSP providing more flexibility than the previous system.

III. Features common across probes

Each node uses a micro-SD card for storage and the commands for file management, networking, configuration and routine operations are the same for the whole system. To speed up prototyping and ease debugging no auto-route algorithm was deployed. The base station can configure route tables in any node so an initial manual entry ensured a safe deployment. Thus the seismic surface nodes route RS485 packets to/from 868MHz radio transparently. Similarly the serial-connected ice probes route to the 151MHz nodes in the ice. Manual route discovery and reconfiguration can be initiated if it is decided that the network topology needs changing.

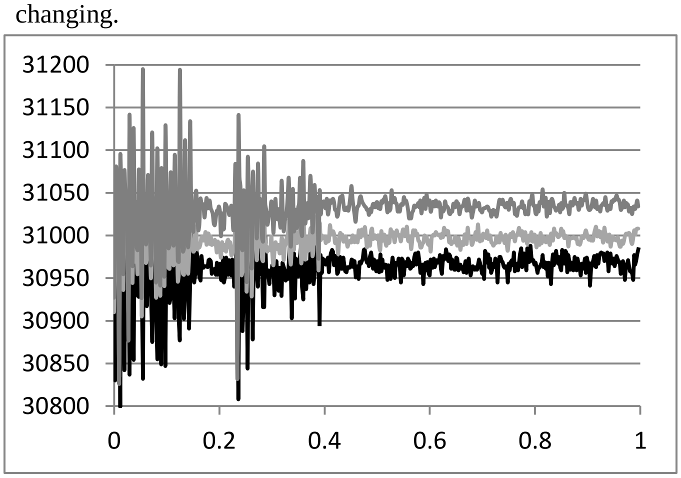

Fig. 2 Example data from a geophone probe showing the different between an event and background noise levels

IV. Conclusion

This work has shown that a heterogeneous network can be deployed to monitor the natural environment. The exact specification of the sensors needed and deployed will vary depending on the exact conditions to be monitored. However, as demonstrated in this work the most appropriate technology can be used for each sub system, and then combined together using an intelligent gateway node (in this case the base station) to collate the data before transfer.

Acknowledgment

This work could not have been achieved without the field work contributions of Alex Clayton, Jeff Gough, Dr Kathryn Rose, Sarah Stock and Dr Richard Waller.

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