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Towards autonomous in-situ data acquisition with wireless sensor networks

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In-situ sensing is a key element of the monitoring infrastructure in polar regions. Sensors deployed in the field measure local conditions; they are an ideal complement to remote sensing for data collection and data assimilation purposes. Today, in-situ sensing is essentially performed at weather stations, i.e., with limited scope and density. To reach their full potential, in-situ sensing systems should cover larger geographic areas, around the weather station and in remote regions.

Two of the key challenges for such in-situ sensing systems are (i) the lack of communication infrastructure, and (ii) the fact that the system might have to run unattended for significant periods of time (because the region in which the system is deployed is difficult or expensive to reach, or because the system is burried under a thick layer of ice in winter).

A way to tackle these challenges is to equip sensors with storage, computation and communication capabilities to form a wireless sensor networks. A cluster of such sensors motes can cover hundreds of square meters. Each sensor is equipped with a short range radio. Data aquired by each sensor can be transmitted, possibly in multiple hops, to the cluster head that accumulate the data and transmit them to the back-end infrastructure using a satellite link. This way a single satellite link is multiplexed across an array of sensors. The embedded storage and computation capabilities on each node are used to trade data processing for data transmission in order to save energy.

The data collected by such a sensor network should be usable for scientific purposes, i.e., it should meet given quality requirements. Second, the limited resources of the sensor network should be ptimized to provide data of the highest possible quality with or without a human supervisor.

The challenge we are focusing on at University of Copenhagen is to design an in-situ data acquisition system that takes as input a description of the data to be collected, and a list of objectives in terms of the quality of these data, and that outputs raw data, their lineage and how well they meet the given requirements. The first step is to define criterias for the quality of the data and to devise appropriate solutions to meet these criteria.

A relatively straightforward data quality criteria is the yield, i.e., the number of data points actually captured over the total number of data points that could be captured. Meeting such a criteria is an open research issue. We are investigating techniques inspired from control theory.

A very ambitious data quality criteria is scientific relevance, i.e., given a set of hypotheses: what data should be collected to confirm or infirm those hypothesis. Meeting such a criteria requires solving the autonomous experimentation problem. The Science 2020 working group expects a solution to this problem within 10 years.