WSN mobility support for Long Term Water Monitoring

Philippe Dallemagne, Damien Piguet, Antonio Restrepo, and Martin Sénéclauze

CSEM SA – Real Time Jaquet Droz 1 – 2002 Neuchâtel, Switzerland
{philippe.dallemagne, damien.piguet, antonio.restrepo,
martin.seneclauze}@csem.ch

Keywords: Wireless Sensor Network, Water Monitoring, Mobility, Routing, Localisation.

Abstract. The objective of the MOBESENS project is to create a system and the necessary sensors to enable continuous monitoring of water quality in lakes and at sea. This paper presents the innovations of the project in terms of wireless sensor network to achieve this goal. After a short description of the project, the paper describes the localization and routing protocols specifically designed to support long term continuous monitoring of water quality.

1 MOBESENS

Management of water quality requires regular measurements and today, this process is conducted manually. The main reasons are the cost of the sensors and absence of remote access to the sensed information. The slow and fastidious manual tasks involved need to be automated and extended to ensure systematic and efficient monitoring. This is the main objective of MOBESENS, a 3 year FP7 European Project. Besides creating new sensors, efficient energy harvesting and facilitating signal processing, the project develops a wireless sensor network specifically targeted to the specifics of water monitoring. This paper focuses on this last aspect.

The paper begins with a brief presentation of the specific requirements of the application. Long autonomous operation with mobile sensors and robustness are the key requirements. In a second part, we will describe the routing and localization protocols developed for the project. The paper ends with some discussion and perspectives.

2 WSN Requirements for automated water quality monitoring

For robustness and simplicity reasons, the network is made of the sensor nodes plus one or more gateway to relay the measurements over longer distances. All nodes are able relay the information from the sensors to the gateways (or vice versa) in a multihop manner. The number of hops is not limited. However, because nodes may move freely or under control on water, the network topology may change over time.

In MOBESENS, this mobility means:

- localisation of the nodes (relative one to the other or absolute for anchors)
- support for changing topology in communication
- limited energy consumption of the network nodes with a special focus on the communication stack
- capability to control the motion of the node (guidance, trajectory computation and verification)

The sequel of the paper concentrate on the first two aspects.

3 MOBESENS Mobility support

The first characterization of mobility in the system will be the need to localise the nodes to ensure proper tagging of the acquired information. There are many systems tackling the problem of automatic sensor position determination. Each is developed to fulfil a different goal and each is with respect to special constraints.

The most commonly used system for obtaining location information is the Global Positioning System (GPS) [Hofmann03]. It is used for outdoor localization and relies on satellites to achieve triangulation. For the project, the use of GPS should be restricted mainly because of the limited energy supply available.

An alternative is to use relative localization techniques developed for wireless networks. There exists a large corpus of algorithms as shows a rapid search on the Internet. However, when power consumption and the absence of fixed anchors are taken into account, to our knowledge, no result is available.

After a careful analysis, we decided to base our study on stochastic algorithms as the Sequential Bayesian method, widely used on robotic methods [Fox03] to locate a mobile robot. They are specifically designed with mobile wireless nodes in mind [Schenkelaars09] and are implemented as follow: a probability density function is constructed using a Gaussian distribution as explained in. In order to refine the results, different types of models can be applied to the Gaussian distribution. A motion model of the node will restrict possibilities to the places where the node was capable to go in a given time; a map model will restrict area to places where the node was capable of going (land vs water for example) etc...[Seshadri05].

Mobility in communication means that communication quality should not degrade when nodes move. This characteristic is taken into account by the routing algorithm implemented in the Wireless Sensor Network. Many routing protocols are available for all kinds of networks and especially for wireless sensor networks. As the traffic is of convergecast nature, we compared a number of tree-based protocols under mobility scenarios. The lack of adequate performances both in terms of transmission success ratio and energy consumption prompted the development of a new tree-based protocol “Local Messages, Shortest-hop count” (LMSH). Though LMSH showed promising results in mobile scenarios with slow mobility, it is not well suited above a certain degree of mobility. For this reason, we opted for some form of probabilistic

broadcast, a smart flooding protocol in such scenarios. The research is now focused on a hybrid solution with probabilistic broadcast for mobile nodes and LMSH for fixed and slowly moving nodes. The main issue is to find the proper criteria for switching from one protocol to the other one.

The capability of the implanted algorithm to cope with mobility will result mainly in a tradeoff between precision, delay and consumption.

It appears that even though some of these techniques or algorithms could provide great results, they will not be used on the MOBESENS systems. The reasons are often related to the insufficient resources available, in particular in terms of computing power and memory amounts, or they are related to the absence of physical device to support implementation.

As a consequence, the following techniques and algorithms have been retained for further evaluation on the existing hardware:

- Probabilistic broadcast for the support of mobility in the wireless sensor network, or LMSH algorithm for the support of convergecast traffic within a fixed network. The combination of both algorithms would also allow the support for both situations, provided the probabilistic broadcast approach is regularly updating the information needed by LMSH,
- Sequential Bayesian localisation for the localisation algorithm.

4 Conclusions and future work

In this paper, it was shown how mobility support was introduced in a Wireless Sensor Network and hints were given on what were the needed tradeoffs:

- guidance is requiring localization
- low delay/jitter needed for localisation and guidance has a direct influence on how the routing of the information is conducted
- all this is directly influencing consumption

In those area and in the Wireless Sensor Field in general, the project in bringing two main results:

- An efficient relative localisation algorithm adapted to situations where global positioning can’t be deployed.
- An adapted routing algorithm suited for Wireless Sensor Network where mobility is needed

Future work in MOBESENS will be focused on implementing and conducting tests fields in rivers, lakes and costal area under the supervision of end-user partners to see if repetitive tasks in the domain of mobile water monitoring can be conducted automatically.

5 References:

[Fox03] D. Fox, J. Hightower, L. Liao, D. Schulz, and G. Borriello.Bayesian Techniques for Location Estimation. PervasiveComputing, IEEE, 2(3):24-33, Sep 2003

[Hofmann03] B. Hofmann-Wellenhof, H. Lichtenegger, , and J. Collins. Global Positioning System: Theory and Practice. Springer-Verlag, fourth edition, 1997

[MOBESENSD11] J. Cros, M.L. Tercier-Weber, J-L. Loizeau, A. Grisel, P. Muralt, M. Sénéclauze, P. Dallemagne, A. Hutter, P. D. Mitcheson, L. Dussud, D. Zeghlache MOBESENS System Requirements, 2008

[MOBESENSD31] P. Dallemagne, A. Marzouki, E. Onillon, A. Restrepo and M.H. Zayani Existing mobility support for wireless sensor communication network, control and motion techniques and localisation techniques and algorithms, 2009

[Schenkelaars09] T. Schenkelaars, Sequential Bayesian Localization in Low-Power Wireless Sensor Networks, CSEM Technical Report, Neuchâtel, Switzerland, 2009.

[Seshadri05] V. Seshadri, G. Záruba, and M. Huber. A Bayesian Sampling Approach to In-door Localization of Wireless Devices Using Received Signal Strength Indication. Third IEEE International Conference on Pervasive Computing and Communications, pages: 75- 84, Mar 2005.

Partners: ADASA (ES), CSEM (CH), EPFL (CH), GET-INT (F), Ifremer (F), Imperial College (UK), Microsens (CH), UNIGE (CH).

Acknowledgment: The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 223975.