IPP HURRAY!

www.hurray.isep.ipp.pt

# Technical Report

## Poster Abstract: Smart-HOP: A Reliable Handoff Procedure for Supporting Mobility in Wireless Sensor Networks


**Hossein Fotouhi**

**Mário Alves**

**Anis Koubâa**

**Marco Zuniga**



HURRAY-TR-110202

Version:

Date: 02-24-2011

# Poster Abstract: Smart-HOP: A Reliable Handoff Procedure for Supporting Mobility in Wireless Sensor Networks

Hossein Fotouhi, Mário Alves, Anis Koubâa , Marco Zuniga

IPP-HURRAY!

Polytechnic Institute of Porto (ISEP-IPP)

Rua Dr. António Bernardino de Almeida, 431

4200-072 Porto

Portugal

Tel.: +351.22.8340509, Fax: +351.22.8340509

E-mail:

http://www.hurray.isep.ipp.pt

## Abstract

This poster abstract presents smart-HOP, a reliable handoff mechanism for mobility support in Wireless Sensor Networks (WSNs). This technique relies on a fuzzy logic approach applied at two levels: the link quality estimation level and the access point selection level. We present the conceptual design of smart-HOP and then we discuss implementation requirements and challenges.

# Poster Abstract: Smart-HOP: A Reliable Handoff Procedure for Supporting Mobility in Wireless Sensor Networks

Hossein Fotouhi*, Mário Alves*, Anis Koubâa*#, Marco Zuniga+
*CISTER Research Unit, Polytechnic Institute of Porto (ISEP-IPP), Portugal
#COINS Research Group, Al-Imam Muhammad bin Saud University (CCIS-IMAMU), Riyadh, Saudi Arabia
+Networked Embedded Systems Group, University of Duisburg-Essen, Germany
{mhfg,mjf,aska}@isep.ipp.pt, marco.zuniga@uni-due.de

***Abstract*— This poster abstract presents *smart-HOP*, a reliable handoff mechanism for mobility support in Wireless Sensor Networks (WSNs). This technique relies on a fuzzy logic approach applied at two levels: the link quality estimation level and the access point selection level. We present the conceptual design of smart-HOP and then we discuss implementation requirements and challenges.**

## I. INTRODUCTION

While mobility support has been almost neglected in WSNs literature and applications, it promises to potentiate a new plethora of applications [1,2]. In some of these applications, the lack of network connectivity will not be admissible or should at least be time bounded, i.e. mobile nodes cannot be disconnected from the rest of the WSN for an undefined period of time. In this context, we aim at reliable and real-time mobility support in WSNs, for which appropriate handoff and re-routing decisions are mandatory.

This poster abstract drafts ongoing work on designing a mechanism for taking reliable handoff decisions in WSNs – **smart-HOP**. The main components of smart-HOP rely on Fuzzy logic, which is used to incorporate the inherent imprecision and uncertainty of the physical quantities at stake.

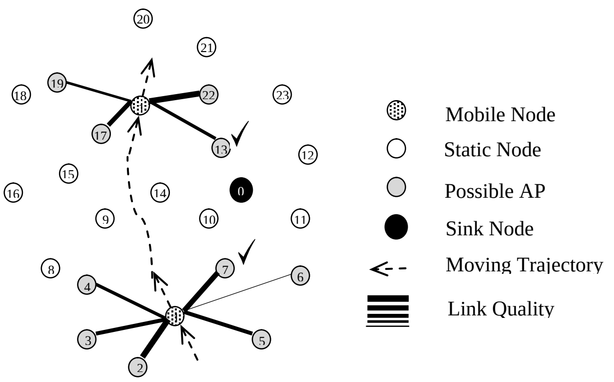


Figure 1 – Network scenario

Handoff refers to the process where a mobile node (MN, e.g. person, vehicle) disconnects from one access point (AP) and connects to another AP (see Fig. 1). Hence, the MN will need to (i) identify the best access point available and (ii) have the capability of switching to a different access point if the quality of communication decreases (handoff).

The remainder of this poster abstract outlines the basics of the smart-HOP mechanism and ongoing work towards its implementation and experimental validation.

## II. HANDOFF MECHANISM

The smart-HOP mechanism relies on a fuzzy logic approach applied in two hierarchical levels: at the link quality estimation level (lower) and at the AP selection level (higher). It consists of two distinct phases (Fig. 2): Phase I aims at taking a quick decision on whether a handoff is needed or not (i.e., it tries to avoid unnecessary handoffs). If a handoff is required, Phase II performs the actual handoff according to a fuzzy based rule.

During Phase I, MN performs an initial assessment of the link quality based on the received signal strength (RSS). We assume that APs periodically broadcast probe messages. Upon reception of multiple probe messages, the MN computes the average of the last “n” number of RSS values ($RSS_{avg}$). The parameter “n” should be set low enough to enable a quick assessment of the radio link (the higher the “n”, the longer it takes) and it should be also set high enough to attenuate (by averaging) sudden RSS fluctuations . If the $RSS_{avg}$ value has not dropped below a certain threshold, the MN keeps associated to the current AP; otherwise it goes to Phase II of the algorithm, to perform a handoff.

In most wireless network protocols, the handoff is merely based on RSS values. We perform the handoff decision based on a more accurate estimation of the radio link quality (using F-LQE - Fuzzy Link Quality Estimator [3]) between an MN and the neighbouring AP, and also on AP-specific parameters such as its energy budget, traffic load and depth in the tree. F-LQE [3] has proved to be more accurate (particularly in the transitional region) than other LQEs as it merges four link quality metrics: (i) packet delivery, (ii) asymmetry, (iii) stability and (iv) channel quality.

In order to choose the best AP, an MN must also assess other criteria apart from link quality estimation: (i) energy level (EL), (ii) traffic load (TL), and (iii) depth level (DL). Each criterion is considered as a fuzzy variable and is assumed to be embedded in the payload of the probe messages. The best AP is chosen with a fuzzy rule comprising the F-LQE membership value together with the previously referred AP-specific parameters. Each of these membership values of the smart-HOP fuzzy decision rule must be weighted. This process is done by assigning a weight to each parameter indicative of its importance, and then, applying the fuzzy decision rule to obtain the final result. We then select the alternative that has the highest grade of membership. Finally, the last step of the algorithm disassociates the MN from the current AP and associates it to the newly selected AP.

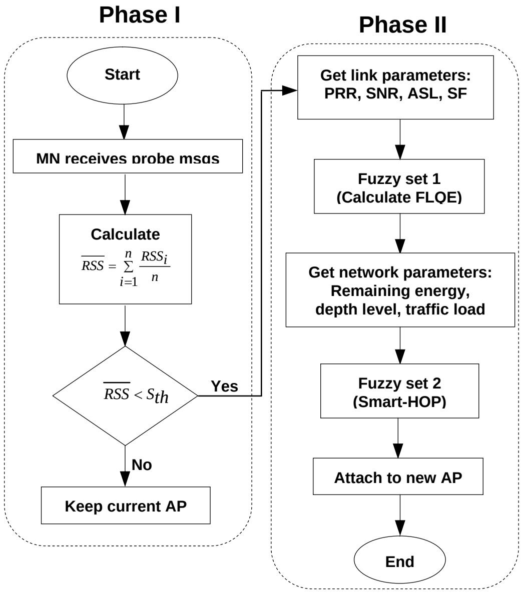


Figure 2– smart-HOP algorithm (simplified)

## III. Ongoing Work

We aim at testing, optimizing, tuning and validating smart-HOP through an experimental test-bed. The smart-HOP is implementing in nesC/TinyOS and integrating it in the IEEE 802.15.4 protocol, specifically in the official stack developed under the TinyOS 15.4 Working Group.

Although a previous implementation of the F-LQE existed [3], we had to re-implement it in a way to be more easily integrated with the IEEE 802.15.4 code and that the collection of radio metrics and computation are determined at run-time.

Link quality metrics must be collected both at the MN and the APs. We embed link quality information (Packet Reception Ratio) of the APs in the IEEE 802.15.4 beacon payload for the MN to perform all necessary F-LQE computations (i.e. stability factor and asymmetry level) at the mobile side.

We intend to use a fixed WSN deployment of TelosB and MICAz motes together with nodes attached to mobile robots. To verify the feasibility of the proposed algorithm under various conditions, the mobile node will be moved at different speeds and in different directions while APs are experiencing traffic load fluctuations.

We will then evaluate smart-HOP under different network topology settings, namely changing the number and location of MNs and APs. In order to facilitate the generation of different link qualities between MNs and the APs, we will generate precise and adjustable interference to affect specific APs.

## IV. Related Work

There are two major families of handoff decision for wireless networks. The most common models are the standard techniques, which are mainly used in cellular, wireless mesh, WLAN, and 6LoWPAN networks (e.g. [4]). These protocols build upon the mobile IPv6 mobility management mechanism. The handoff procedure in mobile IPv6 is initiated by predicting node mobility according to RSS information. The use of the mobile IPv6 technique (purely based on RSS and imposing high packet overhead) is not adequate for WSNs.

Besides the techniques described above, several heuristic models, considering various parameters, have also been reported to handle handoff in wireless protocols. They are widely classified into five groups of dynamic programming [5], pattern recognition [6], prediction-based approach [7], evolutionary algorithm [8], and artificial intelligence [9]. The use of artificial intelligence requires less computational time compared to the other, thus seems adequate for WSNs. In this heuristic group, the fuzzy logic approach describes a system intuitively using linguistic variables. By considering WSN constraints such as limited battery power and the imprecise characteristics of the radio link, the use of fuzzy logic rules seems to be the most efficient heuristic model, and hence, it is the one pursued in our study.

## V. Conclusion

This poster abstract presents ongoing work on the implementation of smart-HOP, a reliable handoff procedure for supporting mobility in WSNs. We outlined a two-phase procedure to take handoff decisions according to several relevant metrics and combining them using fuzzy logic. The algorithm is implemented in TinyOS and is being tuned to get optimal results. We are planning to implement and integrate smart-HOP in standard WSN protocols such as ZigBee and 6LoWPAN, to demonstrate its feasibility and efficiency.

## References


[1] Aline Baggio and Koen Langendoen. Monte-carlo localization for mobile wireless sensor networks, In MSN06, 2006, pp. 317-328.

[2] D. Pompili, I. F. Akyildiz. Handling Mobility in Wireless Sensor and Actor Networks. In IEEE Transaction Mobile Computing. Feb 2010.

[3] N. Baccour, A. Koubâa, H. Youssef, M. Ben Jamâa, D. do Rosario, M. Alves and L. Becker, F-LQE: A Fuzzy Link Quality Estimator for Wireless Sensor Networks, In EWSN 2010, Coimbra, Portugal, Sep 17-19, 2010.

[4] R. Hsieh, Z. G. Zhou, and A. Seneviratne, “S-MIP: A seamless handoff architecture for Mobile IP,” In INFOCOM 2003, pp. 1774–84.

[5] A.Z. Melikov, A.T. Babayev, “Refined approximations for performance analysis and optimization of queuing model with guard channels for handovers in cellular networks”, In ICON 2004.

[6] Wong, K. D. and D. C. Cox, “A Pattern Recognition System for Handoff Algorithms”, *IEEE Journal on Selected Areas in Communication,* Vol. 18, No. 7, July 2000.

[7] P. Bellavista, A. Corradi, C. Giannelli, Adaptive Buffering based on Handoff Prediction for Wireless Internet Continuous Services, In HPCC 2005, LNCS 3726, pp. 1021-1032, 2005.

[8] Chan, T. M., Kwong, S., Man, K. F. & Tang, K. S., Hard handoff minimization using genetic algorithms, Signal Processing, Vol. 82, No. 8, pp. 1047-1058, 2002.

[9] W. Zhang, “Handover Decision Using Fuzzy MADM in Heterogeneous Networks,” In WCNC 2004, Atlanta, GA, March 2004.