

Chapter 15

ROCRSSI++: An Efficient Localization Algorithm for Wireless Sensor Networks

Flavio Frattini

Institute of High Performance Computing and Networking, Italy

Christian Esposito

Università di Napoli Federico II, Italy

Stefano Russo

Università di Napoli Federico II, Italy

ABSTRACT

Localization within a Wireless Sensor Network consists of defining the position of a given set of sensors by satisfying some non-functional requirements such as (1) efficient energy consumption, (2) low communication or computation overhead, (3) no, or limited, use of particular hardware components, (4) fast localization, (5) robustness, and (6) low localization error. Although there are several algorithms and techniques available in literature, localization is viewed as an open issue because none of the current solutions are able to jointly satisfy all the previous requirements. An algorithm called ROCRSSI appears to be a suitable solution; however, it is affected by several inefficiencies that limit its effectiveness in real case scenarios. This paper proposes a refined version of this algorithm, called ROCRSSI++, which resolves such inefficiencies using and storing information gathered by the sensors in a more efficient manner. Several experiments on actual devices have been performed. The results show a reduction of the localization error with respect to the original algorithm. This paper investigates energy consumption and localization time required by the proposed approach.

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INTRODUCTION

Wireless Sensor Networks (WSNs) consist of a massive number of low-cost, low-power and multi-functional small sensors, capable to communicate with other neighbours by means of wireless networks. One of the fundamental issues to efficiently realize a WSN in a real case scenario is *Localization*, i.e., identifying the position of a certain sensor. In fact, there are several real use cases where location-awareness in data dissemination among sensors within a WSN is crucial. Let us consider the case of a WSN used for environmental monitoring, e.g., controlling the occurrence of fire within a forest. The mere information of the presence of fire is not useful if it is not correlated with information on where such fire is present. This is made by attaching to the exchanged messages the location of the sender, e.g., the sensor that detected the fire. Therefore, it is important to be able to determine the location of sensors, so to realize location-aware data dissemination in WSNs.

Localization in WSNs has to satisfy some requirements (Akyildiz, Su, Sankarasubramaniam, & Cayirci, 2002). It is common that sensors are deployed in inaccessible areas, so the substitution of the batteries is very difficult. Moreover, due to the small size of sensors, batteries are small and characterized by short life, and then, energy efficiency is one of the main requirements for these devices. The solution to avoid battery consumption is to use algorithms with low communication and computation overhead without requiring any particular hardware. Moreover, the use of sensors in critical situations implies that localization has to be fast and robust, so that countermeasures can be triggered when a critical situation is detected. In addition, WSNs are usually deployed in challenging environments and sensors make use of wireless network for communicating among each other. Therefore, the adopted algorithm must properly handle phenomena, such as message losses and

signal interference, that may compromise localization. Last, it is required a low localization error.

Most common solutions for localization have been proved to be unsuitable for WSNs, since they are unable to satisfy such requirements (Mao, Fidan, & Anderson, 2007). For instance, the market offers small GPS modules for sensors, but their costs and energy consumption preclude their use in the field of WSNs. Therefore, in recent years, both academia and industry have developed several localization algorithms tailored on the characteristics of WSN. They can be broadly classified in *range-based* or *range-free* localization algorithm, depending if the location is computed by estimating the absolute point-to-point distances among the sensors or relative distances. Another adopted classification is based on how localization is performed. It can be centralized, i.e., a single sensor is responsible of localizing all the other sensors, or distributed, i.e., each sensor will take care of computing its own position by properly interacting with other neighbouring sensors. In this work, we have preferred to use a range-free and fully-distributed algorithm. This is motivated by the consideration that range-free algorithms do not require complex hardware, and centralized ones are difficult to be realized in a real case WSN due to the resource limitation of sensors in terms of computation power, memory and communication overhead.

In this work, we have adopted “Ring Overlapping Based on Comparison of Received Signal Strength Indicator” (ROCRSSI) (Liu, Wu, & He, 2004), which estimates sensors location by considering the overlap of rings of finite definite thickness by comparing RSSI values received by some neighbouring sensors. This algorithm has been proved in previous works, such as (Liu & Wu, 2005), to require few computations, to exhibit low communication overhead, and to achieve the best localization accuracy among the range-free algorithms. However, such algorithm is affected by (1) inconsistency, (2) variable RSSI, (3) channel asymmetry, (4) memory and com-

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