Chapter 9
Energy Efficient and Secure Localization in Wireless Sensor Networks:
An Approach Through Anchor Mobility Control

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ABSTRACT

This chapter describes the development of energy efficient and secure localization systems for wireless sensor networks (WSNs) based on anchor mobility control techniques. Towards improvement of energy efficiency and security over the network, sensors are assumed to broadcast messages in a periodic and coherent manner. Moreover, anchor is supposed to be location aware with GPS (global positioning system) receiver and capable of finding the directions of arrival (DoA) from intercepted signals using smart antennas. In each step along its trajectory, anchor communicates only with neighboring nodes having received signal strength (RSS) above a predefined threshold level. Mobility control schemes aim to explore few new nodes along with the existing ones in each subsequent anchor steps. Sensors would be able to localize themselves after receiving range (distance/angle) data from two distinct anchor positions. Accordingly, convergence speed of localization process is optimized. Simulation results corroborate its competency comparable to the existing methods.

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INTRODUCTION

Currently, several important communication services both in civil and defense sectors, very often require simple and cost effective wireless network architectures (Akyildiz, Su, Sankarasubramaniam, & Cayirci, 2002). In these cases, the sink or base station (BS) also needs to be located at a convenient and safe place for uninterrupted operation throughout the networks. For example, monitoring of disaster-prone areas, military surveillance, or mobile target detection and tracking in the battlefield etc. are normally operated from a remote control room. Wireless sensor network infrastructures, consisting of a plentiful of low power micro sensor devices enabled with integrated sensing, processing and short distance communication capabilities, have been a good choice for such applications until now (Pazzi & Boukerche, 2008). However, these essentially require location based data from the sensors that needs to be relayed to the sink for realization of an event occurring within the harsh fields. Although, in practice, huge static tiny sensors are randomly deployed over the area of interest from an aircraft/vehicle, they remain scattered, unattended and unaware of their locations in most of the cases. Hence, localization systems are also required to be incorporated urgently in such networks for any location based application as mentioned earlier (Boukerche, Oliveira, Nakamura, & Loureiro, 2007).

Basically, the conventional localization systems work with their two constituent parts such as: (i) location estimation process and (ii) localization algorithm. Usually, the former functional segment performs position computation with/without measuring the range (distance/angle) information and hence it is classified into two categories as: (a) range-based and (b) range-free techniques. However, range-based schemes show more accuracy over its counterpart at the cost of system complexity (Biswas, Mitra, & Naskar, 2014). On the other hand, the latter section signifies operating principles of the process how it propagates throughout the entire networks. Again, it may take two forms as: (a) centralized and (b) distributed techniques. In fact, distributed systems often outperform the centralized one, reducing the amount of central coordination and thus, each sensor is capable of acting independently over the networks (Xiao, Chen, & Zhou, 2008). Accordingly, the network attributes like energy efficiency, scalability and robustness etc. are enhanced to some extent. Thus, most of the state-of-the-art localization systems are of distributed features. They also involve few location aware nodes (static/mobile), termed as anchors or beacons, as references in position computation (Zou & Chakrabarty, 2004; Ou, 2011).

However, lifetime of wireless sensor networks is usually dependent on power handling capacity of the battery driven tiny sensors. Hence, a control on proper utilization of the power is very crucial towards their sustained operation to fulfill a specific task. In this regard, reducing the consumption of energy at each sensor might be a strategic approach (Iguchi-Cartigny, Ruiz, Simplot-Ryl, Stojmenovic, & Yago, 2009). But it also appears to be a rather complicated and challenging task since the sensors function in a cooperative manner. Consequently, sensing a large volume of raw data and then communicating them to the neighbors involve a significant amount of power loss. Again, static sensor networks inherently possess some coverage problem after a random deployment because relocation of the sensors is not possible in such cases (Wang, Srinivasan, Wang, & Chua, 2008). Instead, mobile sensor networks can provide intelligent coverage over the networks. But they also become energy inefficient due to their additional power consumption in mobility assistance (Wu, Cho, D'Aurrio, & Lee, 2007). Hence, only tradeoff exists on including few mobile anchors along with static sensor networks making the entire net-

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