Chapter 19
Routing Optimization and Secure Target Tracking in Distributed Wireless Sensor Networks

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**ABSTRACT**

Due to the limited energy supplies of nodes in wireless sensor networks (WSN), optimizing their design under energy constraints, reducing their communication costs, and securing their aggregated data are of paramount importance. To this goal, and in order to efficiently solve the problem of target tracking in WSN with quantized measurements, the authors propose to jointly estimate the target position and the relay location, and select the secure sensor nodes and the best communication path. Firstly, the authors select the appropriate group in order to balance the energy dissipation and to provide the required data of the target in the WSN. This selection is also based on the transmission power between a single sensor and a cluster head (CH). Secondly, the authors detect the malicious sensor nodes based on the

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I. INTRODUCTION

Wireless Sensor Network (WSN) is defined as highly distributed networks of small and lightweight wireless nodes, which are deployed in large numbers to monitor the environment or system by measuring physical parameters such as temperature, pressure, or relative humidity (Chen & Zhao, 2005). Due to their small size, sensor nodes are typically powered by lightweight batteries, which are difficult to replace or recharge. Thus, WSN is a typical energy-restricted network. As observed in most applications, the communication power consumption accounts for about 70% of the total power in WSN (Akyildiz et al., 2002), i.e., most energy of sensor nodes is spent in the exchange of routing information and data. A direct consequence is that sensor nodes will use up their energy quickly, which is uneconomical. Recently, researchers have proposed a special type of node called a “relay node” which is responsible for routing data packets. By using relay nodes, each sensor node would be able to send only its own data without a need to relay traffic from others (Wang et al., 2005). To this goal, minimizing the communication costs between sensor nodes is critical to extend the lifetime of sensor networks. Another important metric of sensor networks is the accuracy of the sensing result of the target in that several sensors in the same cluster can present redundant data. Because of physical characteristics of sensor networks, such as distance, modality, or noise model of individual sensors, the data packets generated from different sensors can have various qualities. Hence, the accuracy depends on the selection achieved by the cluster head on sensors and communication links.

In this chapter, we address the problem of secure target tracking, relay localization, and sensors selection using WSN based on quantized proximity sensors. Target tracking using quantized observations is a nonlinear estimation problem that can be solved using estimation solutions such as unscented Kalman filter (KF) (Julier & Uhlmann, 2004), particle filters (PF) (Djuric et al., 2003) or variational filtering (VF) (Snoussi & Richard, 2006).

Recently, the VF has been proposed as an efficient solution for solving the target tracking problem since: (i) it respects the communication constraints of sensors, (ii) the online update of the filtering distribution and its compression are simultaneously performed, and (iii) it has the nice property to be model-free, ensuring the robustness of data processing.

There has already been a certain amount of research in the area of relay node placement estimation, sensors selection, and secure target tracking for wireless sensor networks. Li et al. (Li, Kao, & Ke, 2009) have proposed a Voronoi-based relay node placement scheme to balance the energy consumption of each sensor node spent in communication. Bari et al. (Bari, Teng, & Jaekel, 2009) have studied the relay node placement with a mobile data collector. Iranly et al. (Iranli, Maleki, & Pedram, 2005) have addressed the joint problem of secure target tracking using the variational filtering (VF) framework.

information relevance of their measurements. Thirdly, they select the best communication path between the candidate sensor and the CH. Then, the authors estimate jointly the target position and the relay location using quantized variational filtering (QVF) algorithm. The selection of candidate sensors is based on multi-criteria function, which is computed by using the predicted target position provided by the QVF algorithm. The proposed algorithm for the detection of malicious sensor nodes is based on Kullback-Leibler distance between the current target position distribution and the predicted sensor observation, while the best communication path is selected as well as the highest signal-to-noise ratio (SNR) at the CH. The efficiency of the proposed method is validated by extensive simulations in target tracking for wireless sensor networks.