Herd-Based Target Tracking Protocol in Wireless Sensor Networks

Xiaofei Xing\textsuperscript{1}, Guojun Wang\textsuperscript{1,2,*}, and Jie Wu\textsuperscript{2}

\textsuperscript{1} School of Information Science and Engineering, Central South University, Changsha 410083, China
\textsuperscript{2} Department of Computer Science and Engineering, Florida Atlantic University, Boca Raton, FL 33431, USA
csgjwang@mail.csu.edu.cn

Abstract. Target tracking is a killer application in wireless sensor networks (WSNs). Energy efficiency is one of the most important design goals for target tracking. In this paper, we propose a herd-based target tracking protocol (HTTP) with the notions of node state transition and herd-based node group for target tracking. A sensor node has three states, namely, sleeping state, sensing state, and tracking state. Each sensor node is associated with a weight to be used to make a state transition among the three states. When a target moves into a monitoring area, a cluster node is selected as the herd head that is responsible for reporting the target information to the sink in the network. The sensor node can adjust the frequency of data reporting according to the velocity of the target. Simulation results show that HTTP not only improves the energy efficiency, but also enhances the tracking accuracy.

Keywords: Wireless sensor networks, target tracking, energy efficiency, node state transition, herd-based node group.

1 Introduction

Wireless sensor networks (WSNs) [1, 2] consist of a set of sensor nodes, each of which is a self-contained unit with a low-speed processor, one or multiple sensors, a radio module, and a battery module. The sensors in a WSN system are deployed over an area in an attempt to sense and monitor interesting events or to track the mobile targets or people as they move through the area. So it is widely used in military battlefields, environmental monitoring, traffic transportation, medical diagnosis, and many other fields. Target tracking is one of the killer applications in WSNs. Because of the uncertain movement of the target, it becomes a challenging issue to position and track the moving target effectively and efficiently.

WSNs have the advantage in high accuracy, real-time, and low cost in tracking the target by using random and uniform distribution and mutual cooperation of sensor nodes. Because of energy constraints of sensor nodes, which are closely

* Corresponding author.
related to the lifetime of the network, the designed target tracking protocol should be able to track the target accurately with low energy consumption. This study can be applied to many target tracking scenarios, such as military tank movement, vehicle movement, wild animal environments, and so on.

We study the issue of tracking mobile targets using wireless sensor networks. The whole tracking process is divided into the positioning stage and the tracking stage. In the process of target tracking, a lot of factors affect energy consumption, which includes the number of moving targets, the speed of moving targets, data reporting frequency, tracking data accuracy, data collection frequency, and so on. Obviously, as design goals, the sensor nodes surrounding the moving target should be able to promptly provide reliable status information about the moving target and the area around it in an energy efficient way, and the sensor nodes should report this information to the sink in a fast and energy efficient way.

In this paper, we propose a herd-based target tracking protocol (HTTP) for single-target tracking in WSNs. In summary, the key contributions of this paper are as follows.

– The herd-based node group which consists of sensor nodes in the tracking state can track the target dynamically by using the node state transition mechanism and weight calculation mechanism.
– An appropriate threshold can be obtained to decide whether the sensor nodes should participate in tracking target or not.
– The data reporting frequency can be adjusted according to the velocity of the target to reduce unnecessary data transmission and improve the energy efficiency.

The rest of the paper is organized as follows: Section 2 summarizes some existing target tracking protocols in WSNs. Section 3 discusses the basic ideas behind the proposed HTTP protocol, including node state transition, node weight calculation, and the initialization and reconstruction of the herd-based node group. An extended HTTP is discussed in Section 4. We simulate and evaluate the proposed HTTP protocol in Section 5. Section 6 concludes the paper.

2 Related Work

Target tracking in wireless sensor networks has been investigated extensively. As one of the fundamental problems with target tracking, energy efficiency has been researched from different aspects. Lee et al [4], Niyogi et al [5], and Wang et al [6] propose prediction mechanisms to restrict the amount of transmitted messages and to select the nodes that participate in target tracking. A dual-prediction-based data aggregation scheme to decrease the communication overhead is proposed in [7]. Considering the tradeoff between tracking quality and energy efficiency and guaranteeing an acceptable tracking quality, some strategies are proposed in [8], [9] to keep the sensor nodes in sleeping state as long as possible.