Computer Networks 162 (2019) 106854

Contents lists available at ScienceDirect

Computer Networks

journal homepage: www.elsevier.com/locate/comnet

Continuous object tracking protocol with selective wakeup based on practical boundary prediction in wireless sensor networks

Seungmin Oh[a], Hyunchong Cho[b], Sang-Ha Kim[b], Wanseop Lee[c], Euisin Lee[a,*]

[a] *Chungbuk National University, South Korea*
[b] *Chungnam National University, South Korea*
[c] *Korea Minting, Security Printing & ID Card Operating Corp., South Korea*

ARTICLE INFO

Article history:
Received 18 October 2018
Revised 2 April 2019
Accepted 6 July 2019
Available online 8 July 2019

Keywords:
Wireless sensor networks
Continuous objects
Selective wakeup
Prediction
Grid
Asynchronous

ABSTRACT

In wireless sensor networks, the selective wakeup approach to activate minimum sensor nodes for object tracking is considered as an attractive way for efficient energy consumption. Different from individual tracking, continuous object tracking is necessary to maintain only sensor nodes on the boundary of continuous objects in the active mode. Recently, a prediction-based scheme, named PRECO, is proposed to energy-efficiently track a continuous object using a selective wakeup scheme. It continuously predicts the next boundary position of a continuous object through mathematical computing and activates sleeping sensor nodes on the next boundary to detect the object in advance. However, PRECO has critical problems for practical implementation in terms of three domains: space, quantity, and time domains. We propose a new continuous object tracking protocol that practically predicts and accurately detects a continuous object at the right time by solving the problems in the domains. To avoid high complex prediction in the space domain, a virtual cell-based prediction scheme is applied to estimate next diffusing areas of continuous object. To reduce the number of nodes for the prediction participation in the quantity domain, our protocol requests only cell heads for estimating the diffusing area of the object and announcing the decision. To remove synchronous prediction in the time domain, each cell head asynchronously predicts the next diffusing area of the object without collaboration with other cell heads. Simulation results conducted in various environments verifies that our protocol is superior to PRECO in terms of energy efficiency and prediction accuracy.

1. Introduction

Wireless sensor networks (WSNs) are self-organized with a large number of sensor nodes that have restricted battery power and low computing power. The WSNs have been used for supporting a variety of monitoring applications, ranging from habitat monitoring to military surveillance [1–3]. Among them, object tracking, monitoring the location of mobile objects in sequence, is one of the most typical applications in WSNs. Most traditional studies on the object tracking have concentrated on individual objects, such as people, animals, and vehicles. Recently, researches on tracking continuous objects, such as wild fires, mud flows and oil spills are actively studied [4,5]. Different from an individual object, a continuous object is a large-scale phenomenon and released from a specific source-spot and then diffused towards the nearby regions [4]. Moreover, its shape grows irregularly and changes dynamically according to environmental or natural effects such as geographical features and winds.

While individual object tracking focuses on the current location of a target object, continuous object tracking emphasizes the current shape of a target object due to the fact that a continuous object is irregularly diffused over a wide area unlike an individual object. To identify the shape of a continuous object, monitoring only the boundary of the object is generally sufficient because the boundary of a continuous object is consecutive and encloses the object [6,7]. Thus, the information from the boundary nodes, which refer to the sensor nodes that are near the boundary of a continuous object, is more important than that from the other nodes. In this view, most of previous studies mainly focus on reducing communication costs by aggregating the reporting messages of boundary nodes for saving energy. Nevertheless, energy is still wasted if all sensor nodes are in active mode. Therefore, an effective strategy is that only boundary nodes maintain in active mode, while the other nodes are in sleep mode for minimizing energy consumption by sleep-wakeup mode switching of sensor nodes.

* Corresponding author.
E-mail addresses: smoh@chungbuk.ac.kr (S. Oh), hccho@cclab.cnu.ac.kr (H. Cho), shkim@cnu.ac.kr (S.-H. Kim), wslee@komsco.com (W. Lee), eslee@chungbuk.ac.kr (E. Lee).

https://doi.org/10.1016/j.comnet.2019.07.010
1389-1286/