Cluster-Based Energy-Aware Localization Algorithm for Wireless Sensor Networks

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***Abstract*— Energy efficiency has become a main challenge in Wireless Sensor Networks (WSNs) and their applications. Localization is one of the indispensable stages in WSN. Localization generally refers to the process of locating the position of one or more node(s) in a network. This paper develops and evaluates an improved energy aware localization algorithm in WSNs. Clustering techniques have been intensively presented in the literature as energy efficient techniques. The proposed approach enhances the AlWadHA localization algorithm by integrating it with the DUCA clustering scheme in order to save the energy and consequently prolonging the WSN life time. The proposed algorithm is implemented using the Castalia 3.2/OMNet++ WSN simulator. The experimental results indicate that the proposed technique maintains the same level of localization accuracy of the AlWadHA algorithm while reducing the energy consumption of the network.**

I. Introduction

A wireless sensor network (WSN) is a network of autonomous devices called sensors that is used to monitor physical or environmental situations, such as temperature, motion, pressure, vibration, or pollutants, at different locations. Size and cost limitations on sensor nodes result in typical limitations on resources such as energy, memory, computational speed, and network bandwidth. Therefore, there is a major need for automated network self-configuration and observation of WSNs.

Most applications of WSNs require knowledge of the position of the sensing nodes. The process of defining the position of the WSN nodes is called localization. There are various challenges for designing effective WSN nodes localization algorithms for real sensor network applications. Estimating nodes position with reasonable accuracy, keeping the sensor hardware simple, using minimum number of known-position nodes and reducing energy consumption of the WSN nodes are the main challenges.

Clustering is a frequently utilized method for enhancing the efficiency of energy consumption and improving the performance of WSN nodes. Clustering nodes into groups saves energy and decreases network disputes because the nodes communicate their data over shorter distances to their cluster heads. The cluster heads then forward the aggregated information to the base station. Thus, only the cluster heads transfer far distances to the base station.

Hereafter, a brief discussion on some related works on localization and energy saving in WSNs with clustering algorithms is introduced. ***First,*** we discuss the state of the art in the WSN localization algorithms.

Several researchers presented detailed overview on various localization algorithms for WSNs. Amitangshu Pal [1] presented a survey for the WSNs localization algorithms developed till 2010. While Kulkarni et al. [2] focused on the utilization of Particle Swarm Optimization (PSO) in various WSN stages including localization.

Abu-Mahfouz et al. [3] proposed "AlWadHA" a localization algorithm for wireless ad hoc sensor networks with high accuracy. This algorithm reduce the number of reference nodes used for estimating the other WSN nodes via using smart reference-selection methodology.

Zhang et al. [4] proposed a localization algorithm for WSN. Their proposed algorithm is based on fuzzy c-means for optimally selecting the beacon node groups. Each group consists of three beacon nodes and a number of unlocalized nodes. Each group can be considered as a circle with beacon nodes in the center and unlocalized nodes on the circle boundary. The simulation results showed a significant reduction in localization error. However, Zhang et al. [4] did not investigate the effect of their localization algorithm on the energy consumption of the WSN.

Abbas and Qasem [5] presented an anchor-based localization scheme for wireless sensor networks. Their scheme is distributed, asynchronous, and scalable. They examined the impact of sensors transmission range and the number of anchors on the error of localization. However, they did not investigate the impact on the energy consumption. Tatham and Kunz [6] investigated the impact of anchor nodes on the positioning error of localization algorithms. They used Curvilinear Component Analysis method for their study. They proposed an anchor-based localization algorithm that utilize minimum number of anchor nodes.

Shunyuan et al. [7] proposed an range free anchor-based localization algorithm that relied on PSO to reduce the distance estimation error. Their results showed that their algorithm resulted in higher positioning accuracy than Distance Vector-Hop (DV-Hop) algorithm. However, energy consumption was out of their scope.

Second, we review clustering algorithms that have been utilized in WSN. Zainalie and Yaghmaee [8] proposed a clustering for localization (CFL) algorithm. It tried to minimize the number of clusters while maximizing the number of nodes