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A Comparative Study of Range-Free and Range-Based Localization Protocols for Wireless Sensor Network:
Using COOJA Simulator

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ABSTRACT

Wireless Sensor Network is deployed in many fields including military operations, mechanical applications, human services, smart homes, etc. However, deploying WSN encounters many challenges. One of the challenges is localizing the node position, especially mobile targets in critical situations. In this paper, the authors compare two types from range-free localization algorithms and one type from range-based algorithms, namely: Received Signal Strength (RSS), Centroid, and Distance Vector Hop (DV-Hops) protocols, using Cooja simulator. RSS localization algorithms require determining values of the RSS from the anchor nodes around the mobile node, to calculate the distance between the unknown mobile and the first three anchor nodes in the mobile range. The centroid localization requires only three anchors to compute the location of the mobile sensor without the need for distance measuring. Lastly, the DV-Hop algorithm uses routing tables of each anchor in the network topology to compute the Average Distance of Hops. The results show that rang-based algorithms are more accurate than range-free.

KEYWORDS

Ancho, Centroid, Contiki SO, COOJA, DV-Hop, Localization

INTRODUCTION

With the exponential growth in the technology of micro-electromechanical system (MEMS), wireless networking and wireless sensor networks (WSN) are consequently improving (Katiyar, Chand, & Soni, 2011). WSN is the base of Internet of Things (IoTs), (Belli et al., 2016) (Sun, Liu, Ma, Liu, & Sun, 2016). The later developments in low-control wireless technology (Liu et al., 2013) motivated us to consider WSN in our work. WSN is constructed of various wireless sensor nodes, which shape a sensor field and a sink. These sets of fields and sinks have the capabilities to sense their surrounding environment, perform a constrained calculation and communicate wirelessly to form WSNs (Al-Karaki & Kamal, 2004).

In WSN, nodes can be classified into three categories: an anchor (aka beacon), localized and unknown. The anchor node has the ability to identify its current position using an equipped GPS device. The localized node is localized manually using network layouts. lastly, the location of unknown node is unknown, neither accurately nor by estimation (Almuzaini & Gulliver, 2010).

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The built-in features of WSNs make the node's location an important factor in determining their state. The information related to the node position represents a vital factor for most WSN applications. In such applications, the estimated information is useless without knowing the exact position from where it was acquired (Chen, Yang, Chang, & Chu, 2009). Localization can be used in many applications such as sensing, tracking, alerting, routing enhancement and traffic management. Such kind of services made WSNs valuable tools for observing characteristic phenomena, natural changes, controlling security, evaluating activity streams, checking military application and tracking friendly military forces in the front lines. These duties require a very high unwavering reliability of sensor networks (Mao, Fidan, & Anderson, 2007).

Recently, numerous localization methods are (Sheltami, 2015) (Shahzad, Sheltami, & Shakshuki, 2016). Localization protocols are classified into: range-free and range-based, centralized and decentralized (distributed) (Singh & Sharma, 2015). In range-based approach, nodes decide their position taking into account angle or distance calculation from some anchor nodes with well-known positions. Such estimations may be obtained through diverse procedures, for example, time of arrival (ToA), time difference of arrival (TDoA), angle of arrival (AoA) or receive signal strength indicator (RSSI) (Shen, Wang, Jiang, Lin, & Sun, 2005). Due the equipment limitations of sensor devices, range-free localization mechanisms are a financially distinct option for the costlier range-based methodologies. There are two fundamental types of range-free localization protocols that were recommended for sensor networks, including: (1) Local strategies that depend on a high thickness of points of interest so that each sensor node can hear a few historic points. This is represented by centroid algorithm, and (2) Hop based strategies that depend on flooding the connectivity information in the network such as hop count. This represented by DV-hop algorithm (Liao, Shih, & Lee, 2008).

The centralized approach requires the data transmission data to a central node with a specific end goal to compute the mobile node location. This process is fairly expensive due to the fact that the power for every sensor is constrained, and the long-range multi-hop information transmission. Therefore, the constrained power accessibility at every sensor node implies that any connection with a facility of centralized computing is costly. Besides, sending time arrangement information inside of the network presents latency and in addition, expanding energy and network data transfer capacity. On the other hand, using decentralized localization, methodologies require less connection between sensor nodes and subsequently decrease the power consumption of the WSN. Additionally, decentralized localization frameworks need equipment to be joined to every portable target to acquire the localization data from reference nodes, calculate its position and transfer its present position to a central PC (Chen et al., 2009). The focus of this work is to study a different set of algorithms that are used for both range-free and range-based localization. Performance and accuracy of these algorithms are then compared.

To the best of our knowledge, an extensive comparison of range-based and range-free protocols has not done yet in the literature. The remainder of this paper is organized as follows. The next section explores the related work in the literature related to localization using both range-based and range-free protocols. Then, we present and investigate the localization algorithms to be compared in this paper. Next, we discusss the simulation results produced using COOJA simulator. Finally, the last section concludes this work.

RELATED WORK

A huge amount of work is effectively done in the field of localization. In this section, a number of localizatoin approaches are reviewed. Additionally, a work that is directly related to this work is illustrated. In (Alhmiedat & Yang, 2008), the authors concentrate on tracking the mobile node by distributing low-density sensor node. They used a new approach that improved the accuracy of