

One Anchor Distance and Angle Based Multi-Hop Adaptive Iterative Localization Algorithm for Wireless Sensor Networks

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ABSTRACT

This paper presents distance and angle measurements based Multi-Hop Adaptive and Iterative Localization algorithm for localization of unknown nodes in wireless sensor networks (WSNs). The present work determines uncertainty region of unknown nodes with respect to known (anchor) nodes using noisy distance and angle measurements. This node transmits its uncertainty region to other unknown nodes to help them determine their uncertainty region. Because of noisy distance and angle measurements, the error propagation increases the size of regions of nodes in subsequent hops. Using only one anchor node as reference, the proposed iterative localization algorithm reduces the error propagation of this noisy distance and angle measurements and the uncertainty region of all unknown nodes within a given communication range. The results clearly indicate the improved efficiency of the proposed algorithm in comparison with existing algorithms.

Keywords: Angle of Arrival (AOA), Localization, Received Signal Strength (RSS), Time Difference of Arrival (TDOA), Time of Arrival (TOA), Wireless Sensor Networks (WSNs)

I. INTRODUCTION

Developments in the field of electronic devices, components and in modern communication technologies has lead to the development of small, cheap, and smart sensor nodes (Stojme-

novic, 2005; Akyildiz, Su, Sankarasubramaniam, & Cayirci, 2002). Hundreds or thousands of such nodes, able to sense the environment, compute simple tasks and communicate with each other, form a huge wireless sensor network (WSN) (Chong & Kumar, 2003). Collected information (e.g., temperature, humidity etc.) from relevant node then transmitted in a multi

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hop fashion over direct neighbors to a data sink, where the data interpreted and action taken accordingly.

Localization in Wireless Sensor Networks (WSNs) refers to creation of a map of a WSN by determining the geographical coordinates of each and every node. A number of applications of WSNs like target tracking (Li, Wong, Hu, & Sayeed, 2002), forest fire surveillance, fluid quality monitoring in industry, intrusion detection, traffic management etc require information about physical location of sensor nodes in the network. Localization also helps in geographical data packet routing (De, Qiao, & Wu, 2003) and collaborative information and signal processing (Heidemann & Bulusu, 2000). More over once location of a node in network is known, the coordinates that eventually will save the size of data packet to be sent by it can simply replace its node ID. Many limiting aspects of a node like computation intensity, power consumption and memory location imposed by the small devices is to be considered in location identification in a WSN. Because of the random deployment nature of WSN, it is not feasible to place nodes while recording their locations one by one. A network consisting of 1000 nodes will require around 17 hours to localize whole network assuming 1 minute required for placement of each node while recording its location.

One possible solution is to equip nodes with GPS. But limiting factors like small size, limited computation power and energy source, the possible solution excludes use of GPS. In almost all localization techniques some percentage of nodes are assumed to know their location a priori. Nodes which know their location a priori are called anchors. These anchor nodes help in absolute localization of nodes in a WSN. Without any anchor, nodes create a local map of their own which may be translated, rotated or mirror image of the actual map. These anchor nodes may be the nodes placed manually while recording their locations or nodes with additional capability like GPS as in (Meguerdichian, Slijepcevic, Karayan, & Potkonjak, 2001). The percentage of anchors required for localization of a WSN depends upon the technique of local-

ization adopted. The proposed algorithm uses only one anchor node with RF beam steering capability to localize a full WSN. Simulations show that only one anchor node is capable for localization of a WSN within an acceptable level of error in localization.

Rest of the paper is organized as follows. Section II describes the problem associated with localization of sensor nodes followed by the related work in section III with proposed solution in section IV. The simulation and results are given in section V. Conclusion in is Section VI.

II. PROBLEM STATEMENT

We define the localization problem as estimating the smallest region which has the highest probability of having a node. With the available hardware and software support, any node within one hop from anchor can determine its uncertainty region w.r.t. anchor node from data sent by anchor with received signal strength index (RSSI) and angle of arrival (AOA) measurements. Before working on an algorithm based on above measurements, the uncertainties and their effects need to be taken into consideration. Therefore we discuss these uncertainties as under:

- A. **Uncertainty due to noisy distance measurement:** With available RSSI, the distance between two nodes can be approximated by:

$$U_{j2} = U_{ki} \oplus U_{k1} \quad (1)$$

Where \tilde{d}_{ij} is the distance between node i and node j , P_{tx} , power transmitted by i th node, P_{rx} power received by j th node and ∞ , the propagation constant. Because of the inherent irregularity in RSSI measurement especially indoors due to multipath effects, it becomes practically impossible to predict exact distance

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