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A Novel Localization Scheme with Path Planning Mobile Anchor in Wireless Sensor Networks

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***Abstract**: Wireless sensor networks have potential to become the pervasive sensing (and actuating) technology of the future. For many applications, a large number of inexpensive sensors are preferable to a few expensive ones. The large number of sensors in a sensor network and most application scenarios preclude hand placement of the sensors. Determining the physical location of the sensors after they have been deployed is known as the problem of localization. In this paper, we proposed a novel localization technique based on a single mobile beacon aware of its position (e.g. by being equipped with a GPS receiver). Sensor nodes receiving beacon packets infer proximity constraints to the mobile beacon and use them to construct and maintain position estimate. As a range free technique so no extra hardware is necessary. This proposed technique is able to work in case of both anisotropic and isotropic networks.*

***Keywords:** Wireless sensor network, Localization, Mobile beacon, Range free, Anisotropic, Isotropic, Travelling trajectory, Rendered Path protocol, Grid scan algorithm.*

1. INTRODUCTION

The Large numbers of untethered sensing devices are bound to revolutionize the way we interact with the physical world [1]. Recent advances in sensing, processing and communication made possible tight integration of a complete sensor node on a single chip [2]. On-chip integration enables inexpensive production of large numbers of such sensors. Being deployed in large numbers results in better coverage of a geographical area, but it also poses numerous challenges to the communication protocols. From tactical surveillance and target tracking to environmental monitoring and space exploration, the applications of sensor networks is limited only by our imagination. For most applications, sensed data without spatial and temporal coordinates is of very limited use. Sensor nodes have to be aware of their location to be able to specify "where" a certain event takes place. Therefore, the problem of localizing the sensors is of paramount importance for many classes of sensor network applications. Sensors aware of their position can also improve routing efficiency [3]–[6] by selective flooding or selective forwarding data only in the direction of the destination. Sensor nodes may not have an individual identifier (i.e. address); the Distance or angle metrics are used to determine the location of the sensor node in Range-based schemes. Time of Arrival (ToA), Time Difference of Arrival (TDoA), Angle of Arrival (AoA), Received Signal Strength Indicator (RSSI) are the distance and angle metrics. Range-based techniques are highly accurate as compared to other techniques. But the main drawback is it should be provided with expensive hardware hence increasing the cost of the entire network and it requires lots of computation. Examples of this technique are DV-distance, DV-hop, and Euclidean distance [12], Multidimensional Scaling (MDS) Radio Interferometry Measurement (RIM) [13]. The information transmitted by nearby anchor nodes/neighboring nodes is used to identify the positions of the robustness of the sensor node in range-free technique which is based on one hop or on location of the sensor may be (part of) the address of the sensors. Various algorithms that use the location as part of the address have been proposed [7]–[10]. The position of each sensor can be manually introduced if the sensors are hand-placed; however, when the number of sensors is large, this becomes a tedious and error-prone method of localization. In many applications, hand-placing the sensor is not an option. If the sensors are scattered from a plane or from a mortar shell, a different localization method has to be employed. If each sensor node has a global positioning system (GPS) [11] receiver, the problem becomes trivial. However, having a GPS receiver on every node is currently a costly proposition in terms of power, volume and money. This implies that it would be beneficial to look at existing and proposed approaches to identify the challenges and suggest future research directions.

The rest of the paper is organized as follows. Section II describes the prior works. The proposed technical approaches are described in section III. In section IV, conclusion is added.

2. LITERATURE REVIEW

2.1 Range based and Range free Techniques

triangulation basis. Examples are chord selection approach, three dimensional multilateration approach [14], centroid scheme etc. The critical issues of range-free technique are accuracy and communication overhead. Range free techniques are cheaper than range based techniques.

2.2 Mobile Beacon Localization

The beacon messages are transmitted by mobile anchor to determine the location of the sensor node proposed by Sichitiu and Ramadurai [15]. From beacon messages received signal strength indicator is used as one of the main parameter to estimate the location of the sensor node. Based on a single mobile anchor, a distributed localization scheme was proposed by Galstyan et al. [16]. A more robust and accurate localization solution can be obtained by using estimation techniques related to non parametric probabilistic mechanism. TOA technique is used in this approach for ranging and utilizes centroid formula with distance information to calculate the sensor node's position. Based on trilateration localization scheme Han et al. introduced a path planning scheme for mobile anchor. According to the equilateral triangle trajectory, the anchor node moves in the sensing field and broadcasts information about its position. Making use of the trilateration method sensor node will calculate its individual position. Based on the received signal strength distance between the anchor node and sensor node can be calculated. The main disadvantage of the RSSI ranging technique is inaccuracy. If the sensors are deployed indoors, walls would continuously reduce the precision of the method due to nonlinearities, noise, interference and absorption. A technique based on connectivity-induced constraints [17] for finding out the unknown node location in sensor network. Known peer-to-peer communication in the network is modeled as a set of geometric constraints on the node positions. The solution of a feasibility problem for these constraints yields estimates for the unknown positions of the nodes in the network. One disadvantage of the method in [17] includes a central point of computation with the associated traffic overhead, scalability and reliability issues.

3. PROPOSED APPROACH

The main idea of this paper is to eliminate the some of the drawbacks of existing localization systems. The main problem is more number of anchor nodes are using they are more expensive than the rest of the sensor nodes This means that, even if only 10% of the nodes are anchors, the price of the network will increase tenfold. Another observation is that after the unknown nodes have been localized, the beacons become useless; they no longer use their (expensive) GPS receivers. The reasoning mentioned above leads us to believe that a single mobile beacon can be used to localize the entire network.

To understanding the effectiveness of the proposed method we give a description of the localization method proposed by K. F. Ssu et al. [18]. In this method, a single mobile anchor node moves through the network and periodically broadcasting information about the current coordinates of the mobile anchor node and each sensor node receives location of the anchor. In [18], it is assumed that the communication range of the sensor node can receives messages (beacon message) from the mobile anchor node is bounded by a circle. To calculate the location of the sensor node using the fact that the perpendicular bisector of a chord of a circle passes through the center of the circle. For that minimum three beacon points required. Based on author's observation, when the length of the chord is short, the unsuccessful localization will increase as shown in "Fig. 1". To overcome this, an enhanced path planning mobile anchor based scheme is developed. To understanding the effectiveness of the proposed method we also give a description of the Rendered Path: Range-Free Localization in Anisotropic Sensor Networks with Holes proposed by Li Liu et al. [19]. This [19] proposed Rendered Path (REP) protocol is a range-free scheme for locating sensors in anisotropic WSNs with holes. By path rendering and virtual holes construction operations in a distributed manner, REP is able to accurately estimate the node-to-node distances and calculate node locations with only 3 seeds. But REP does not presume the superior communication capability of seeds, i.e. with much larger radio range than those of the ordinary nodes. Our proposed Localization scheme is able to overcome this problem.

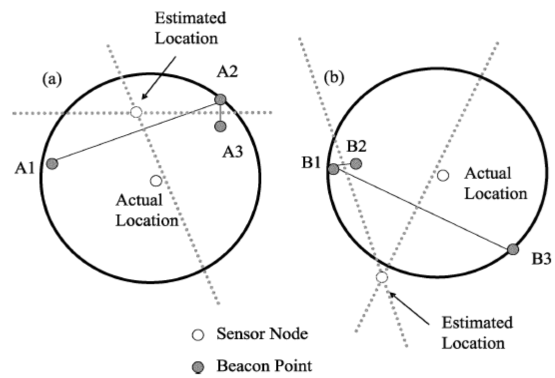

Figure 1: Short chord problem (Unsuccessful Localization)

MBAL: A Mobile Beacon-Assisted Localization Scheme for Wireless Sensor Networks [20] and An Efficient Localization Scheme with Ring Overlapping by Utilizing Mobile Anchors in Wireless Sensor Networks [21]-these two papers are developed for the isotropic networks. But they do not work in case of anisotropic networks.

3.1 Proposed mobile anchor path planning scheme

"Figure 2" depicts a wireless sensor network deployed over a geographical area. In a real environment, most localization algorithms do not take different shape of the WSN area into consideration.

To improve the localization coverage and accuracy of unknown nodes, the proposed algorithm optimizes the traveling trajectory of an anchor node. An anchor node moves according to equilateral distance trajectory in a deployment area (see in "Figure 2"). The mobile anchor node broadcasts a position message to unknown nodes with the equilateral distance at the beacon point in "Figure 2".

After deployment the anchor node moves in the entire sensor network in a predefined path (travelling trajectory) while broadcasting beacon packets. The beacon messages contain the mobile anchor node id, location, timestamp. Any other sensor node receiving the beacon packet will be able to infer that it must be somewhere around the mobile beacon. On encounter of signal from anchor node within the transmission range, a beacon point is marked. The beacon point is considered as an approximate centre point of the sensor node's communication circle. After two or three communication circles are obtained, the sensor node is estimated as the common area of those circles. After deployment, a grid scan algorithm is used. In this algorithm, a grid array is used to represent the maximum area in which a node will likely reside. If obstacles will appear in realistic environment network, we used the Rendered Path (RED) protocol [22] as shown in "Figure 2".

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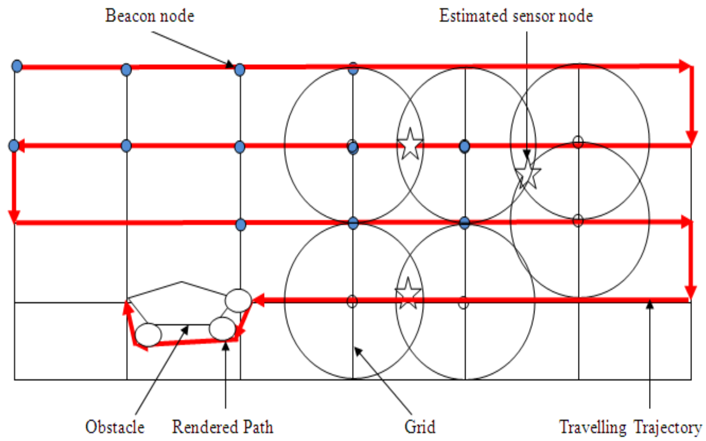

Figure 2: Pictorial view of Rendered path

4. CONCLUSIONS

We proposed enhanced technique for localizing the randomly deployed sensor nodes in wireless sensor network. Based on the location information from the single mobile anchor, the sensor nodes calculate their individual positions. The proposed technique is scalable, effective and efficient as the anchor node is made to move so it can cover the entire network area. The short chord problem before mentioned is solved as well as it has been shown that all sensor nodes can determine their location in the presence of obstacles in the sensing field.

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