A Descriptive Study on various Localization Schemes for Localization of WSNs

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Abstract

This paper presents the several localization techniques for the wireless sensors networks and the need for localization. Localization is estimating the position or spatial coordinates of wireless sensor nodes. The localization problem has received considerable attention in the past, as many applications need to know where objects or persons are, and hence various location services have been created. Undoubtedly, the Global Positioning System (GPS) is the most well-known location service in use today. A few of the developed and emerging techniques has been discussed in the paper.

Keywords: Localization, Routing, WSN, Range based Localization

I. INTRODUCTION

A wireless sensor network (WSN) is a distributed collection of nodes which are resource constrained and capable of operating with minimal user attendance. The nodes are distributed spatially to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants at different locations. Such nodes are usually embedded in the physical environment and report sensed data to a central base station. The base station (or gateway) can communicate with a number of wireless sensors via a radio link. Data is collected at the wireless sensor node, compressed, and transmitted to the gateway directly or, if required, uses other wireless sensor nodes to forward data to the gateway. The transmitted data is then presented to the system by the gateway connection.

Many wireless sensor network applications require that the locations of the individual sensors be known, since sensor readings are in general of little use without geographic context. Localization is estimating the position or spatial coordinates of wireless sensor nodes. Localization is an inevitable challenge when dealing with wireless sensor nodes, and a problem which has been studied for many years. The localization problem has received considerable attention in the past, as many applications need to know where objects or persons are, and hence various location services have been created. Undoubtedly, the Global Positioning System (GPS) is the most well-known location service in use today. The approach taken by GPS, however, is unsuitable for low-cost, ad-hoc sensor networks in terms of volume, money and power consumption, since GPS is based on extensive infrastructure (i.e., satellites). Likewise solutions developed in the area of robotic and ubiquitous computing are generally not applicable for sensor networks as they require too much processing power and energy.

II. NEED FOR LOCALIZATION IN WSNs

Localization in wireless sensor nodes is important due to:
1) Localization enables the efficient routing: A typical sensor network has large number of nodes which communicate at very short distance (a few meters). The data sensed by a node has to be communicated to the central unit (or a sink) through several other nodes.
2) Localization provides the power saving: Suppose we have deployed the sensor network for pollution monitoring. Now the neighbor sensor nodes will have data which will not be dramatically different from each other.
3) Localization assists in the applications like target tracking: In this application, we typically need to determine the range, speed and the direction of the target.
4) Localization is useful in locating the source of the data: In many applications, an event based sensor networks are used. Here, the nodes are normally in sleep mode and when an event occurs (say sudden vibrations take place) then nodes are awakened.

III. VARIOUS LOCALIZATION ALGORITHMS

Localization, deployment and coverage are essential subjects in wireless sensor networks. Localization is one of the important issues, because it is the fundament of many applications. In the applications, sensor nodes have to be aware of their positions to be able to specify a certain event takes place. Therefore, the problem of localizing the sensors is of paramount importance for
many applications of sensor network. Using single localization approach to find the location of sensor may not be most efficient way.

A. Range Based Algorithms

The range methods exploit information about the distance to neighbouring nodes. Although the distances cannot be measured directly they can, at least theoretically, be derived from measures of the time-of-flight for a packet between nodes, or from the signal attenuation. The simplest range method is to require knowledge about the distances to three nodes with known positions (called anchors or beacons depending on the literature), and then use triangulation. However, more advanced methods exist, that require less severe assumptions.

Range-based algorithms compute the location depending on the precise measurement of the point-to-point distance or angle. Several mechanisms have been purposed to localize a node in this algorithm. They include following popular methods and algorithms such as time of arrival (TOA), time difference of arrival (TDOA), angle of arrival (AOA), trilateration, triangulation and maximum likelihood estimation.

B. GPS Based Algorithms

In the case of the Global Positioning System, a synchronization of the atomic clocks in the satellites gives a great accuracy (thus depending on the clock of the receiver), but in the case of wireless sensor networks, the achieved accuracy is very poor: the Telos motes used at the Automatic Control Group have a time stamp of the radio packet with an accuracy of 1 millisecond. Using an acoustic signal will decrease the propagation speed, and thus increase the accuracy. With a precision of 1 ms, the localization accuracy is 35 cm.

C. Mobile Beacon Algorithms

Beacon nodes can be used in several ways. Some algorithms (e.g. MDS-MAP) localize nodes in an arbitrary relative coordinate system, and then use a few beacon nodes to determine a rigid transformation of the relative coordinates into global coordinates. Other algorithms (e.g. APIT) use beacons throughout, using the positions of several beacons to “bootstrap” the global positions of non-beacon nodes. Beacon placement can often have a significant impact on localization. Many groups have found that localization accuracy improves if beacons are placed in a convex hull around the network. Locating additional beacons in the center of the network is also helpful.

The beacon trajectory and distribution of sensor nodes is shown in figure 1. The position of sensor can be calculated with help of beacon node. This algorithm is useful in different ways. Accuracy level is a bit higher than DV-hop algorithm and location can easily be found out. This algorithm is expensive than other algorithms because of global positioning system. It is difficult to find the location of all the nodes in mobile beacon algorithm.

D. Calamari

Calamari is a good compromise and a solution to the calibration problem. The authors showed that normal variations in (for example, transmit frequency, acoustic hardware, etc) between sensor nodes from the same manufacturer may lead to an error up to 300% in the distance estimates. Although these errors could potentially be remedied via higher tolerances on hardware components, calibration would certainly be a much more cost efficient approach.

E. Range Free Algorithms

These methods never compute the distances to the neighbours, but use hearing and connectivity information to identify the nodes and beacons in their radio range, and then estimate their position. Range-free localization methods are being pursued to achieve a cost-effective solution.
F. APIT

The Approximate Point–In-Triangle (APIT) [36] idea is to divide the environment into triangles, given by beaconing nodes. An individual node’s presence or absence in each of those triangles will allow reducing the possible location area. This goes until all the possible sets are exhausted, or the desired accuracy reached.

The APIT algorithm is then ran at every node:
- Receive locations from n anchors.
- For each possible triangle, test if inside or not.
- If yes, add it to the Inside Set.
- Break if accuracy reached.
- Estimate position as Center of Gravity

For testing if the node is inside or not a triangle according to the Point-in-Triangle (PIT) test, it needs to move.

![Fig. 2: Approximate-Point-In-Triangle (APIT) test](image)

Figure 2 shows an example of this process: each of the triangles represents a triple of beacons and the intersection of all the triangles defines the position of the unknown node. The point in triangle (PIT) test is based on geometry.

G. Hop Count

The idea behind this method is that if two nodes can communicate by radio, their distance from each other is less than R with high probability, where R is the maximum range of their radios, no matter what their signal strength reading is. Thus, simple connectivity data can be useful for localization purposes.

![Fig. 3: Hop Count](image)

Figure 3 shows an example of hop-count in which hop-count \( h_{AC} = 4 \). Unfortunately, \( h_{BD} \) is also 4, due to an obstruction in the topology. This is one of the ways that hop count distance metrics can experience dramatic error.

A few of the equivalent algorithms for the localization of wireless sensors nodes are listed below:

1) DV-Hop
2) Multi Hop
3) N-Hop Multilateration
4) Area-based deployment and localization
   - Wide area localization (WAL)
   - Local area localization
   - Ad-hoc localization
IV. CONCLUSION

The localization of the wireless sensors nodes has always been a topic for the discussions among the wireless engineers. A lot can be studied and reviewed over the various hurdles evolving the localization and making the localization schemes efficient for the future. A few of the techniques have been reviewed in this paper and leaves the researchers with lot of scope for the improvement of conventional systems of localization.

V. FUTURE SCOPE

Advancements in the technology in WSNs always leave the researchers with a wide space for the improvements in the current trends of localization schemes. Security in the localization of wireless sensor networks can be looked as a future scope.

REFERENCES


